SCIENTIFIC AMERICAN

No. SUPPLEMENT 663

Scientific American Supplement, Vol. XXVI., No. 663. Scientific American, established 1845.

NEW YORK, SEPTEMBER 15, 1888.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

YELLOWSTONE PARK.

ONE of the Dublin guide books remarks, with truth possibly, "The Phœnix Park is the largest in the world, with the exception of the Yellowstone National Park, in the United States," but the author does not mention that the exception has the modest dimensions of fifty-five miles by sixty-five miles.

This enormous tract, larger than the County of Devon, has, by a noble and timely act of the United States government, been preserved intact, so far as its wonders are concerned, while every facility for viewing them will be granted by means of good roads, which are gradually replacing the old trails.

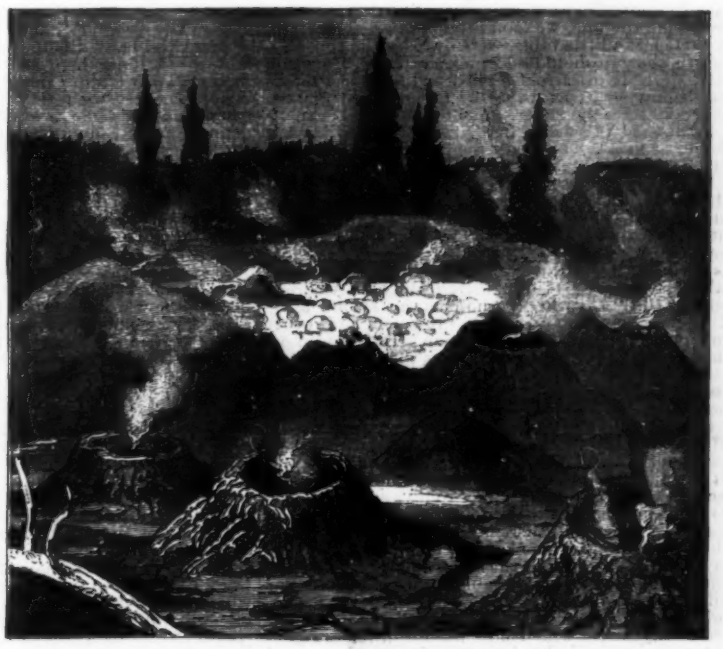
To Dr. F. V. Hayden, the United States Geologist, the credit is due of the idea of setting apart this region of wonders for the pleasure and instruction of the citizens of his country.

Bills for the purpose were introduced in 1871, into the Senate by the Hon. S. C. Pomeroy, and into the House of Representatives by the Hon. William H. Claygett, of Montana, and with little opposition passed into law.

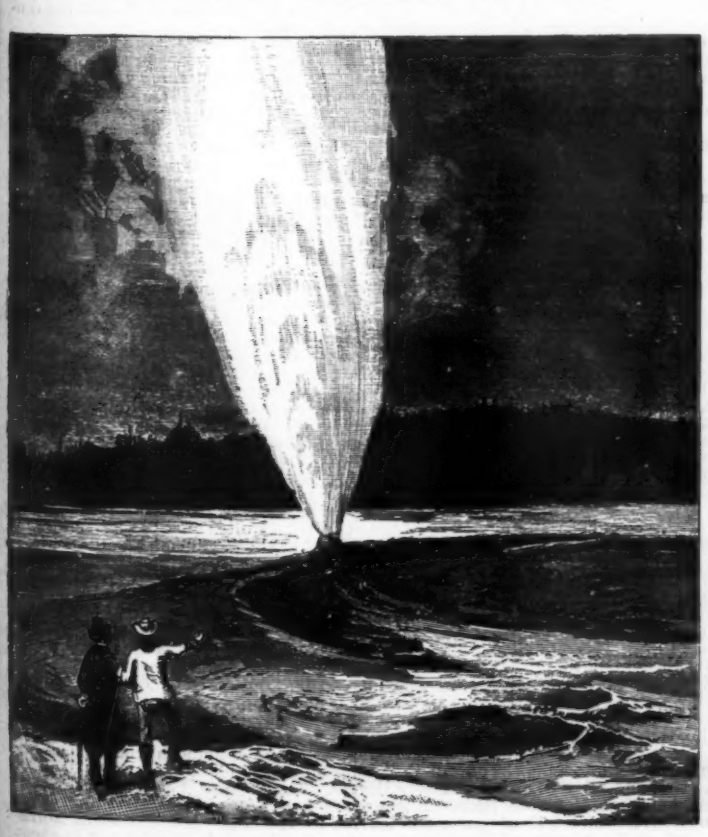
When we call this area a park, we must allow our imagination to work freely about the term, or, at least, we must admit of great arithmetical progression. If an English park may contain within it woods, hills, meads, lakes, and ravines, and may be divided into, say, the "home" and the "deer" park, we are to find in the Yellowstone Park all these, enlarged in ratio with the area. The woods are miles of dense forest, living or dead, wherein we may ride for hours under the tottering fire or frost smitten trunks, or view where the cyclones have carved their roads of ruin. The hills are mountains of 4,000 feet above the Park level, the meads are prairies, the ravines are tremendous gorges, sometimes exceeding 1,000 feet of depth, the fish ponds are lovely little lakes, lily-covered and with beaver dams, the Great Lake is a vast sheet of water, twenty-five miles by thirty miles; the "deer" to be looked for are the great "elk" (wapiti), moose, and black tail, and the "vermin" the keepers of the Park have to watch for are bear and "mountain lion." The "rock work" is vast cliffs of volcanic glass and mountains of delicate stalactitic fret-work. And as for the fountains of Uncle Sam's Home Park, they are bigger than any in the world, and boiling to boot.

As our "carter," who has sketched all the scenes

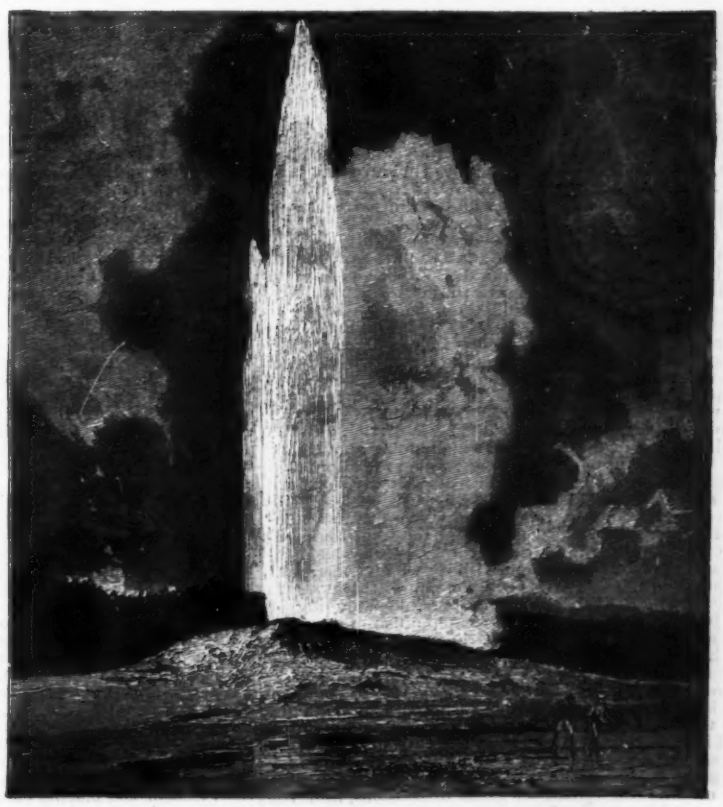
ON THE SHORES OF THE YELLOWSTONE LAKE.



"PAINT POTS," LOWER GEYSER BASIN



THE "BEEHIVE" GEYSER IN ACTION.



"OLD FAITHFUL" GEYSER IN ACTION.

SCENES IN THE YELLOWSTONE NATIONAL PARK.

mentioned in lively language, begins to expatiate on the fountains, his speech gathers force as he proceeds with his wondrous tale, until, overburdened with expletive and illustrative allusions to the realm of Pluto, a slight incoherence takes place, and, turning a bend, we see before us in the evening light the huge wooden hotel of "Mammoth Hot Springs," with green walls and red roof, and beyond it the strange, pale terraces of the "White Mountain," the protruding face of the active portion of the Hot Springs of Gardiner's River, backed by dark pine-clad slopes.

A few minutes, and we are safely landed in the great hall of the hotel, bask in the rays of the electric light, and hear the notes of a pianoforte, whose full, strong tones can hardly be those of another maker than Steinway. Rather bewildered by these evidences of the march of progress, we proceed to that registration and colloquy with the clerk which is so great an institution in American travel, and here a disappointment occurs when we add our home addresses—Hosh-Kosh, Mich., and Bullock-Smithy, Eng.—the clerk does not extend a hand to each, and question us earnestly as to the health and well-being of a friend of his, and ours, at each of these places; for once, only once, the American hotel clerk was not omniscient, and we felt discouraged.

As we ponder this strange thing, our hand is touched by what feels like a calf, and an odor as of a farm floats around; we turn and find a gentleman enveloped in buffalo skin who wishes also to register. We resign the pen and look around us. The hall runs apparently from end to end of the building; but, at one end, is closed by curtains. They open for an instant, and disclose the dining room. Around huge upright stoves in the long corridor groups of tourists, carters, and hunters, most characteristic of Western ways, are seen, and in long, long perspective a line of classically shaped vermilion spittoons extends in an array at once economically convenient and severely architectonic.

Following the line, we soon lifted the great curtain, and, seated at a little table, were deep in the consideration whether we should select elk steak or bear from the Western dainties registered upon one of Prang's most elegant *menu* cards. Our friend voted for the former; we took the latter. As it was our first experience, we tasted of each other's dish, and also tried a little moose meat. The result reminded us of the opening to Hans Andersen's story: "There were two little toy soldiers who were brothers, for they were both made out of the same leaden spoon." Similarly, we found that in the Yellowstone elk, moose, and bear meat are brothers, for they are all made out of the same old bull.

As we made this discovery voices were heard without speaking with that varied inflection which, in America, proclaims the "Britisher:" the curtains swung aside and disclosed a genial English professor and other members of the British Association. But, ah! how changed from the point-device aspect they possessed at our last meeting—brown, with sun scars upon their noses, fly bites round their eyes, frost chaps across their knuckles, beards of a fortnight, and garments more or less frayed off all projecting points, they presented a fearful sight to incoming tourists.

We fraternized, joy was unconfined, and, together with a genial German gentleman who knew the Park, we settled to the consideration of route and "transportation." There can be little doubt about the former; in regard to the second there is the question of driving or riding. For both there is every facility, and a party of say, five, can hire one of the before mentioned "rigs," or stage wagons, upon reasonable inclusive terms. For smaller parties of gentlemen riding may be recommended; the traveler is freer, and the ponies, called "cayuses," which are let for hire, are generally untiring and hardy, even if, one here and there may appear at the morning saddling or "sinching" to have graduated at the "Buffalo Billeries." The experienced at our council all advised riding, and that we should get ponies, our German friend assenting, adding, without full appreciation of the English idiom, "I would advise you to bekom* ponies. I would myself bekom a pony when I had not a bad lek, for which I visit dese sbrings." We afterward had the opportunity of seeing that good arrangements for testing the therapeutic value of the springs were made, and although this cannot as yet be fully known, sufficient success in the treatment of articular maladies, rheumatism, and cutaneous diseases has been achieved to show that, as a sanatorium, Mammoth Hot Springs has a great future before it, and will be the salvation of many a bad leg, arm, or body, as a whole.

A lovely morning gave us every opportunity for seeing the Mammoth Hot Springs at their best. Before the hotel spread a gray plain, dotted with clumps of wormwood, young pines, or ithuja bush. In the midst stood a strange pyramidal object, some fifty feet in height, called the "Liberty Cap;" beyond were the Terraces of glistening white or yellow, passing into brown, still in formation. Clouds of steam were reeking up and dispersing among the pine trees that clothed the hill sides above. In order to understand the whole system of the Terraces, it is well to descend from the hotel, which stands upon one of them, to the level of the Gardiner River, which flows about 1,000 feet below the uppermost springs, which are about two miles back from the river. Three great divisions are observable. The old Spring Terraces, at and a little above the level of the river, upon which are a few insignificant vents, and a small stream of high temperature which, falling into the Gardiner, enables the fisherman—now for the incident without which no account of the Yellowstone Park is complete, and which we are anxious to get over as early as possible—standing at the junction of the streams, to catch a fish in the cold, and stew it in the hot water without removing it from the hook, or feeling any remorse for the cruelty of the operation.

From these extinct Terraces a sharp rise of some 400 feet brings us to the plain upon which the hotel stands, and which, though now broken in surface and crumbled by atmospheric influences, shows that at no very ancient date it was the theater of very imposing phenomena. At one point a deep chasm shows the position of a boiling spring of great dimensions, and the curious "Liberty Cap" remains as witness of a geyser of special interest. This isolated shaft of forty-five feet in height, with another upon which the Terraces are encroaching, named the "Giant's Thumb," are the only geyser orifices having a great length of tube above the surface. The cone of the "Giant," of which we shall have to speak later, has a height of some twelve feet only.

But *the* "Terraces," that lovely mass of delicate and vari-colored incrustation pierced with pools, the color of which no pen can describe, which travelers willingly cross the continent to see, are there, above us, forming the third great platform of the "White Mountain." All portions of this are still active, but the lower part, a tract of about one hundred and seventy acres in extent, is that which comprises the special beauties which give to Mammoth Hot Spring Terraces their renown, beauties which, now that the greater terraces of Rhotomahana have been destroyed, are unique.

The most interesting points are three. Minerva Terrace from below the level, the Pulpit Terrace, and the former Terrace with its source, the lovely Cleopatra Spring, looked at from the slightly higher ground of what are called the main springs.

Given a fine clear day of August or September, nothing can be more strangely beautiful than the aspect of the Minerva Terrace, as one struggles along in the broken down, powdery, geyserite formation, toward it.

On the left are the fine terraces surrounding the Main Springs, on the right a mass of deposit forty feet in height, and covering, perhaps, an acre. At differing levels project from the general mass huge cups, bearing a rough resemblance in form to halves of those great sponges we see in museums called "Neptune's cups." These projections are various in size, some being as much as eight feet high. The more usual height is four to six feet. The edge of each terrace forms a perfectly straight line, telling with the utmost sharpness in contrast with the curves of the sides, with their delicate wave-like ornamentation and pedestals of slender stalactites. The general tint of the whole terrace is snowy white, varying at different points into delicate yellow and ocher tones, here and there contrasted by a rich brown. As we approach nearer, every basin is seen to be ornamented with tiny hollows and projections, all conforming to some law of harmonious overflow and deposition, and giving one the same sense of craft and workmanship as one experiences in looking at a half effaced stone, carved with cunning knots and enlacements of ancient Celtic art. As we look, closely too, into the lovely pure surfaces shining as the water slides over them, we see that threads of more vivid, but still delicate, tints are adding a beauty of tone by their presence.

As we climb the path between the two terraces the heat becomes intense, and the glare upon the eyes intolerable; we are glad to put on blue or smoke glasses, which no traveler should be without. Arrived at the upper level, we view the Cleopatra Spring itself and the basins which surround it, and an effect of color is spread out before us such as could, we imagine, be seen nowhere out of this region of enchantment. We now see how all the vast cups, the sculpture on the sides of which we have admired, are massed, one outside the other, at various levels around a central group of shallow pools extending over the whole surface of the terrace, in the midst of which opens a spring, consummate in its beauty, of clear water of the deepest emerald, shifting into blue, changing through an infinitude of tints until it is bounded by a thin line of coral-like incrustation; outside of this is curve after curve, sweep after sweep, of the same delicate formation, each curve inclosing a very shallow pool, in which silky threads stir or wave; each pool, according to its depth, or colored bottom, or reflection of sky or cloud, has its own true or passing tint, while over all, here confusing, there receiving, reflection of the hues below, hangs a delicate haze of steam. Thus, looking from the higher level, the spectator has before him a species of natural *cloisonne* enamel on a vast scale, in which the delicate threads of deposit are the *cloisons* and the pure, shallow, many hued pools the enamel. But not in Osaka, nor in the ateliers of Barbedienne is there any *cloisonne* of such opaline hues and laughing tint as that around "Cleopatra's Spring."

We gaze long at this wonderful surface, forgetting that it is only a part of the beautiful panorama which is spread out before the eye, as we stand on the acclivity. Presently we find time to admire the valley to the northward, and the worn slopes of Mount Evarts, crowned with its long rampart of cliffs over against us, before we turn again to the ascent, and to examine further the wonders of this strange mountain side, which seems to be quivering with some mysterious life; for above us, from among the pines which have grown to a forest upon the half extinct terraces, we hear slight noises, and see thin wreaths of steam which betoken activity.

Not so beautiful as the terraces when the springs are in full action, the higher region, where vast extinct terraces moulder under air, frost, and heat, and upon which the forest gradually encroaches, is full of interest, for in it may be studied the anatomy of the formations in the huge breaches which time has made in the cliffs of geyserite, leaving the internal structure open to view, and in caverns from which the boiling streams once gushed or spouted, the interior of which may now be examined.

Of the latter, our illustration of the so-called "Mammoth Cave," named from its locality and not from its size, will give an idea. We find the opening to it upon the crest of a long ridge, small cracks along which show that the aperture is only the largest of a series which are not so roomy, but which probably mark the line of a rock fissure, along the whole extent of which waters holding minerals in solution have gushed, gradually piling a long mound of deposit, through which the waters oozed or spurted until the pressure became withdrawn, and the fissure became sealed.

A portion of one of the finest specimens of this kind of formation may be seen in the termination of the "Narrow Gauge."

A rude ladder of poles allows us to descend to a depth of some thirty-five feet, and at the extremity of the cave we become aware of a heat considerably greater than that of the blazing sunshine above, which tells of our approximation to that mysterious fiery source of energy which exists at no very great depth, causing all the strange phenomena of this Wonderland, and which geologists tell us is probably a mass of still hot lava. The sides of the cavern as they arch over to the elliptical opening above us are coated with carbonate of lime of great hardness deposited in ribs and bosses, and at one of the commissures of the fissure hangs a group of huge oval masses, in shape and color like vast bladders of lard, such as the Gastrolaters might sacrifice to their god Manduce.

Making a circuit westward on our return, we find many curious exemplifications of the action of the springs; at one point a pretty grotto of formation of pure white, streaked with red, brown, and green, is seen against a background of pines, which closely surround it. Again, hearing a strange chattering sound proceeding from a dense grove, we push through and arrive at a space covered with small mounds of geyserite, out of which tiny spurts of water are continually leaping, causing the twittering sound we heard. This is called the "Squirrel" geyser. Further on we find the "Orange" geyser; a small thread of water continually leaps from the summit of a mound of a brilliant orange color. While forming, this mound, like almost all others, has enveloped the trunks of growing pines, which are killed, and stand white and ghostly in the inundation of deposit.

Sketching here, we found ourselves closely watched by several pretty little ground squirrels called "chipmunks," brown, with bodies longitudinally striped, fawn bellies, and short straight tails. They would watch from behind a grass tuft, and then, for a better view, suddenly run to the end of a low branch, or the summit of a hillock, and eye us with the utmost friendliness. As artists, wandering in byways of America, we must express our sense of indebtedness to the "chipmunks" for their constant and cheerful companionship.

Among these woods "back of" Mammoth Springs there is a warm pool much resorted to for bathing. Repairing thither, two heads were discernible upon the reeking surface. That these cloudborne countenances were not those of a species of cherub was presumptively proved by the presence on the bank of a monumental pair of boots, having that plenitude of verge and curve which so loudly proclaims the benefit of protective duties to the American consumer, and by a wide brimmed hat with a neat little rosette upon the band. There could be no doubt in the mind of the observer that there floated before him, in one warm baptism blent, a "rustler" of the Occident and an Anglican priest from beyond the Eastern Ocean. It was a gracious incident, and how suggestive to the mind!

Our course back to the hotel brings us again out upon the Great Terraces, and we have, upon the western side, wonders as great as upon the eastern face we ascended—the singularly perfect group of stalactite basins called the Pulpit Terrace, which, for purity of color and grace of form in the separate cups, cedes to none. In the midst is the "Pulpit" itself, with its lovely decoration of what seems fair white drapery hanging in fluted folds to the base. Mr. Ingersoll's arrangement is apt, in which we see photographed a veteran of the "Grand Army of the Republic" apparently officiating, with, on the pulpit edge, according to a graceful American custom, a bouquet, composed of mallow, willow herb, and local woodland blossoms. This group appears to be quite extinct, and must moulder away in the course of a few years, to be replaced, it may be, by fresh decorations.

Our evening at the hotel was fertile in incident. A party of English tourists had come down from the Park, among their baggage a mysterious box, the contemplation of which, "with one consideration and another," induced a policeman to arrest one of the travelers for the heinous offense of deporting "specimens." This, as our German friend explained with a happy occulation of language, is "streckly verbod." An act had been passed rendering the collection of specimens punishable, but copies of the document had not arrived, so that the action of the minion of the law was considered somewhat premature.

In an outbuilding a court was hurriedly improvised, a justice of the peace of somewhat battered appearance presided. The general aspect of the court and spectators, seen by the light of two small lamps and through a cloud of cigar smoke, might be described as rugose, and seemed to promise justice neat, unsweetened by mercy. The accused was a blond gentleman, whose fairness was in touching contrast to the bronze of the members of the Vehmgericht. The presiding magistrate made a few remarks on the heinousness of the offense so impressively that we emptied our pockets of the geyserite fragments we had therein, and, favored by the gloom, dropped them into the invitingly open pocket of our next neighbor. After the observations of the justice, the proceedings took a somewhat Pickwickian character; it was discovered that the act was not yet quite sufficiently matured for operation, and that the offender had in his collections been solely influenced by scientific considerations. The court broke up, and by detachments adjourned to the "saloon," to the discussion of the *cause celebre* and "Old Bourbon." There we heard the decision of the court colloquialized—

"Nary a fine, fer the act's only come down on the wires; and he weren't a-goin' to sell the sp'c'm'ns, nor give 'em to gels fer toys."

The stringent application of a law against the injury of the beautiful and fragile decorations of the geyserite formations should have every possible support. The energy of the collector is quite equal to the deportation of the "Liberty Cap" or the mound of the "Castle Geyser," and infinite injury can easily be done to the terraces and the coral borders of the hot pools. At the same time, there are places where no injury could be caused by collection of geyserites and geological specimens, and it would be well if some responsible person under, say, the geological survey, were nominated to form and dispose of to museums, etc., collections representative of the very interesting minerals of the region. Otherwise the system of petty purloining, to which even the most virtuous tourist now renders adhesion, must continue.

The central platform of Mammoth Hot Springs, upon which the hotel stands, has an elevation of 6,367 feet above the sea, that is, twice the altitude of Snowdon. But we are here only at the lowest level of the park, and leaving for the next "hotel," that at Norris' Basin, we at once ascend a grade of 2,000 feet in about two miles of road, and then find ourselves upon what may be called the "floor" of the great Alpine plateau, upon which the "Wonderland" is seated. As we crawl up the steep, hot, and dusty slope, we think again

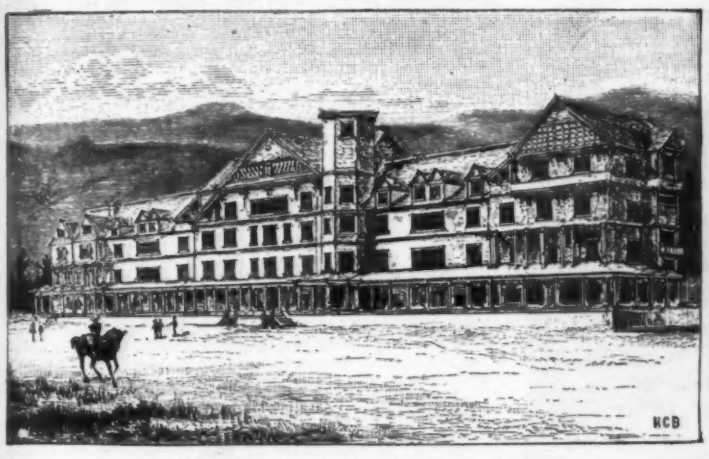
* "Bekommen"—to get, procure.

about the strange characteristics of the region, and begin to appreciate that we are climbing into the central and mysterious citadel of the North American continent—the very heart of the Rocky Mountains—whence flows the chief stream of the greatest river of the continent, and among the peaks and gorges of which the great cyclones gather, and are flung eastward over the thousands of miles of plain and ocean, until they break against the shores of Britain and Norway—a constant war of the gods. Kabibonokka, the ice god of the West, is ever hurling storm and vapor against the fastnesses of Thor.

As we ride up the slope we are striking nearly southward for the first of the great geyser tracts, "Norris," or "Gibbon" Basin, twenty-one miles from Mammoth Hot Springs. From the summit of the grade a magnificent panoramic view is seen looking north, along the Gardiner and Yellowstone Valleys, the crater-like summits of Sepulcher Mountains, the palisade cliffs of Mount Evarts, and in the distant northeast the grand snowy "Electric Peak" towering to over eleven thousand feet. Passing the pretty little "Freda Lake," after a few miles over a somewhat open country, where the sun beats hotly upon the sage scrub, we cross the Gardiner River, keeping along Obsidian Creek toward Obsidian Canon and Cliffs, one of the great wonders of the Park. Ascending the creek, the valley narrows,

CONE OF THE "GROTTO" GEYSER.

"DIANA'S WELL" AND "CASTLE" GEYSER PLUNGING.



MAMMOTH HOT SPRINGS HOTEL.

PULPIT TERRACE—"TAKING DUTY" IN A YELLOWSTONE PULPIT.

THE "ORANGE" GEYSER AND THE "CHIPMUNK."

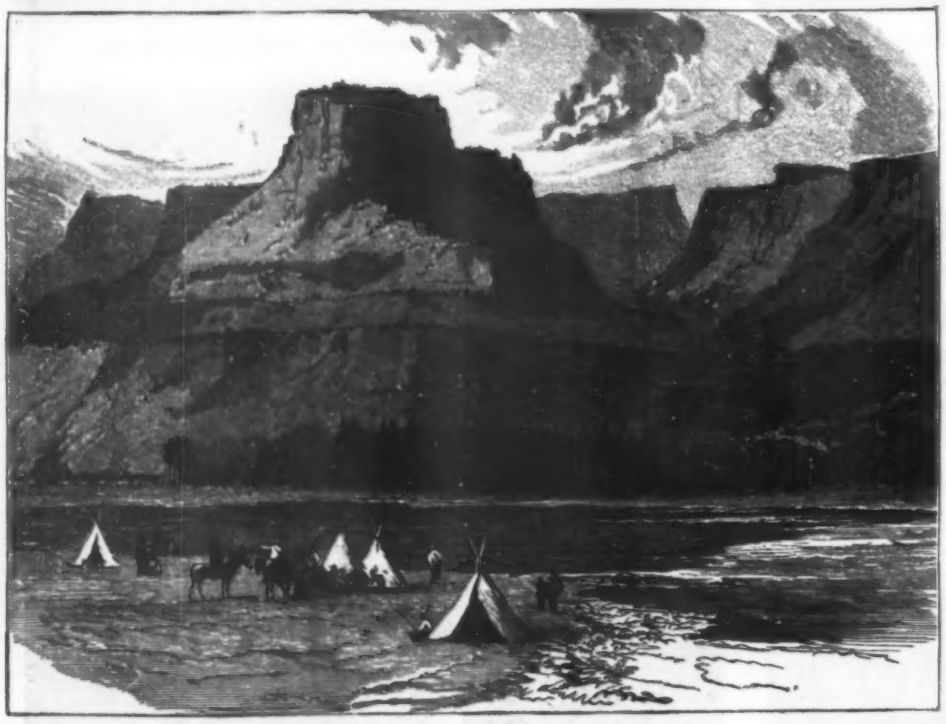
INTERIOR OF AN EXTINCT FISSURE GEYSER, MAMMOTH HOT SPRINGS.

SCENES IN THE YELLOWSTONE NATIONAL PARK.

and the road enters dense forest, until, crossing the stream, it passes a point of remarkable interest. On the right is spread out Beaver Lake, a considerable sheet of water bordered by grassy marshes, and backed up by high hills densely clad with pine. The lower part of the lake is a series of old beaver dams, showing a strange labyrinth of raised banks, inclosing pools mantled with green, with an old beaver hut, forming a little islet on the western side. On the eastern bank the road passes under cliffs of more than two hundred feet high, exclusive of the scree below them, from which the Canon takes its name. The lower half of these cliffs is composed of irregularly shaped columns of volcanic glass, overlaid by another mass not so clearly columnar. Huge rocks of the black cinder have fallen, and form the scree out of which the roadway has been hewn by means of huge fires lighted among the largest blocks, which were splintered when hot by dashing water upon them. The dark lake, the immense black vitrified cliffs set among dense forest, and the burned trunks about the screes, make the whole scene such as Dore might have imaged.

From this vast quarry the Indians appear to have supplied themselves with arrow heads; some fine implements were discovered upon an old trail by the Geological Survey near this spot, and we had ourselves the good fortune to find, near Mammoth, spots where the arrow makers had sat and worked surrounded by their chippings of obsidian, jasper, and chalcedony.

A little further, and the beautiful little "Lake of the Woods" is reached, where, at nearly eight thousand feet, we approach the divide of the waters flowing to the Gardiner, and those of the Gibbon flowing to the Madison. Through forest green or forest burned we press on, and, emerging upon a dislocating piece of



A SKETCH IN THE "BAD LANDS."

corduroy road, cross the stream, and draw up at the row of tents which does duty for a hotel.—*London Graphic.*

THE GREAT MUIR GLACIER IN ALASKA.

THE glacier enters the sea with a gigantic front two or three hundred feet above the water and a mile wide. Fancy a wall of blue ice, splintered into columns, spires, and huge crystal masses, with grottoes, crevices and recesses, higher than Bunker Hill monument, and a mile in width! It is a spectacle that is strangely beautiful in its variety of form and depth of color, and at the same time awful in its grandeur. And not alone is the sight awe-inspiring. The ice mountain is almost constantly breaking to pieces with sounds that resemble the discharge of heavy guns or the reverberations of thunder. At times an almost deafening report is heard, or a succession of them, like the belching of a whole park of artillery, when no outward effect is seen. It is the breaking apart of great masses of ice within the glacier. Then some huge berg topples over with a roar and gigantic splash that may be heard several miles, the waters being thrown aloft like smoke. A great pinnacle of ice is seen bobbing about in wicked fashion, perchance turning a somersault in the flood before it settles down to battle for life with the sun and the elements on its seaward cruise. The waves created by all this terrible commotion even rock the steamer and wash the shores miles away. There is scarcely five minutes in the whole day or night without some exhibition of this kind. There are mountains each side of the glacier, the one upon the right, or south shore, being the highest. High up on the bare walls are seen the scoriated and polished surfaces produced by glacial action. The present glacier is retrograding quite rapidly, as may be seen by many evidences of its former extent, as well as by the concurrent testimony of earlier visitors. On either side is a moraine half a mile in width, furrowed and slashed by old glacial streams which have given place in turn to others higher up the defile as the glacier recedes. These moraines are composed of earth and coarse gravel, with occasional large bowlders. On the north side the material is more of a clayey sort, at least in part, and the stumps of an ancient forest have been uncovered by the action of a glacial river, or overwhelmed by the icy flood. Some scientists claim these forests are in reality pre-glacial, and many thousands of years old. The interior of the great moraines is yet frozen, and at the head of one of the little ravines formed by former glacial river discharges, a little stream still trickles forth from a diminutive ice cavern. Notwithstanding the contiguity of the ice itself, and the generally frigid surroundings, blue bells and other flowers bloom on the moraine. In the center of the glacier, some two miles from its snout, is a rocky island, the top of some ancient peak the great mill of ice has not yet ground down. It is interesting to see how the massive stream of ice conforms itself to its shores, separating above the obstacle and reuniting below. On approaching or departing from Muir Inlet, the voyager may look back upon this literal sea of ice and follow its streams up to the snow fields of the White Mountains, which form the backbone of the peninsula between Glacier Bay and Lynn Canal.

The following facts relating to the Muir glacier, its measurement and movement, are derived wholly from Professor Wright's notes: Roughly speaking, the Muir glacier may be said to occupy an amphitheater which has the dimensions of about twenty-five miles from north to south and thirty miles from east to west. The opening of this amphitheater at Muir Inlet is toward the south-southeast. It is two miles across from the shoulder of one mountain to the other at the outlet. Into the amphitheater pour nine glaciers, and the sub-branches that are visible make the affluents more than twenty in number. Four of the main branches come in from the east, but these have nearly spent their force on reaching the focus of the amphitheater. The first tributary from the southwest also practically loses its force before reaching the main current. The main flow is from two branches coming from the northwest and two from the north. The motion is here much more rapid. Observations made upon three portions of the main glacier, respectively 300, 1,000, and 1,500 yards from the front, showed the movement to be 135 feet at the first point, sixty-five at the second, and seventy-five at the third, per day. The summit of the lower point was a little over three hundred feet above the water, the second 400 feet, and the third considerably more, probably 500 feet. The motion rapidly decreases on approaching the medial moraines brought down by the branches from the east. Along a line moving parallel with that of the greatest motion, and half a dozen miles east from it, the rate observed at two points was about ten feet per day. Thus we get an average daily motion in the main channel of the ice flow, near its mouth, of about forty feet across a section of one mile. The height of the ice above the water in front, at the extreme point, was found to be 226 feet. Back a few hundred feet the height is a little over 300 feet, and at a quarter of a mile 400 feet. A quarter of a mile out in front of the glacier the water is 85 fathoms, or 510 feet deep. Thus Professor Wright estimates that a body of ice 735 feet deep, 5,000 feet wide and 1,200 feet long passed out into the bay in the thirty days he was there, this movement and discharge taking place at the rate of 149,000,000 cubic feet per day. He says that after the fall of a large mass of ice from the glacier into the bay, the beach near his camp, two and one half miles distant from the glaciers, would be wrapped in foam by the waves. One of many large masses he saw floating about projected some 60 feet out of water, and was some 400 feet square. Estimating the general height of the berg above the water to be 30 feet, and its total depth 250 feet, the contents of the mass would be 40,000,000 cubic feet.

The Swiss glaciers, it should be remembered, are contracted affairs in comparison with the Muir glacier, which is four times as wide as the glacier selected by Tyndall for his observations, and six times as large as the whole surface of the Mount Blanc glaciers. Professor Wright is of the opinion that one of the other glaciers entering Glacier Bay is much larger than the Muir. From a pinnacle of elevation overlooking the Muir ice field, which is obtained by an arduous half day's climb, although some expect to accomplish it in an hour, one can count no less than fifteen tributary glacial streams, any one of which is as large as the great Rhone glacier, over which European tourists go into ecstasies. Drawn from the inexhaustible but annually diminishing accumulations of snow which fill the mountain valleys to a depth of at least 2,000 feet, these separate streams of plastic congelation unite like the strands of a rope to form the irresistible current of the Muir. The surface of the glacier is not uniformly level and smooth like a boulevard. It has its drifts and dikes, its cascades, riffs and rapids, like any unfrozen river. In the immediate front, and extending a mile or more back, its whole surface is the most rugged formation imaginable. It is utterly impossible for any living creature to traverse it, being in fact a compact aggregation of wedge-shaped and rounded cones of solid ice, capped by discolored and disintegrating snow. But away back in the mountain passes it is easily traversed with sledges or snow shoes. Indians cross the divide at sundry places along the coast, from the Stikeen to Copper River.—*The Juneau City Mining Record.*

THE GREAT JAPANESE VOLCANIC ERUPTION.

THE following interesting and well written account of the terrible catastrophe has appeared in the New York *Tribune*. It is dated Tokio, Japan, July 23:

"News of an awful and destructive catastrophe has just been received. In the province of Tukushima, near the city of Wakamastu, about 165 miles north of Tokio, a terrible and most calamitous eruption of the apparently extinct Bandai-san volcano has taken place, resulting in the burial under volcanic mud and rocks and ashes of a region of about 75 square miles, and causing more or less damage and devastation within an area extending over more than 675 square miles. It was on July 15. The morning was unusually hot and sultry. At this season of the year peasants from the adjacent regions frequent for the purpose of health and recreation the little mountain hamlet of Iwase and its three hot springs, which are, besides a few weather beaten and partly decomposed scoriaceous rocks cropping out on the surface, the only indications of the volcanic character of a mountain that has been quiescent for about a thousand years, and the crater of which had been filled up long ago by the slow processes of nature. There was no ground for apprehension of any kind, and a few earthquake shocks, felt two or three days previous to the eruption, presented also nothing unusual or abnormal. Earthquake shocks and seismic tremors are common throughout Japan. Some of the people were quietly enjoying the hot baths on the slope of the mountains, others conversed with the visitors that had come from a distance, while a majority were lying on their mats, talking, smoking, dreaming, dozing, sleeping. Old Bandai-san presented his usual appearance, and nature herself, dreamy and drowsy, seemed about to fall into slumber.

"Suddenly, a few minutes past eight o'clock, a low rumbling was heard like the sound of distant thunder, actually believed to be such by some; but before there was time for an interchange of words, the earth was heaved up and began to tremble violently, the ground undulating like water shaken in a bowl. From the peak of Bandai-san there then shot up into the air, as though discharged from the cannon's mouth, and accompanied by a noise as of a hundred thunder storms combined, a huge mass of red volcanic mud, mixed with fire and rocks and sulphur and smoke, carrying with it the very peak of the mountain, and hiding for a time the broad and brilliant canopy of heaven, and then, in its fall, covering the green earth below with a bluish gray winding sheet of volcanic mud, heavy rocks, hot water, burning sulphur, red-hot sand, and glowing ashes of a bluish tint. Under this mass, varying in thickness from 7 to 20 feet, were hidden 600 men, women, and children, dead at once or writhing in the last agonies. Among these there were no less than 150 visitors to the hot springs, who thus found a horrible death in place of the expected cure from sickness and disease. Within a fatal circle described by a radius of five miles around the mountain, few people were able to escape unhurt, but even beyond that distance persons were killed or injured. Dense black smoke continued to issue from the aperture through which the subterranean forces had found vent, and black clouds soon covered the sky far and wide, while constantly recurring earthquake shocks increased the fright of the trembling fugitives. Whoever could, fled at once in every direction away from the smoking crater. Some, stark naked and ashy pale, ran at the top of their speed over the glowing cinders; women fainted and fell from sheer exhaustion and terror; a few, crazed by fright or injured by falling beams and stones, hopped or crept away like so many animals set at large. To increase the horrors of the scene, pine trees, tall and stately and centuries old, were torn from the ground and thrown upward, while sulphurous flames blazed forth between their crackling roots, presenting to the wild and excited imagination of the people the spectacle of weird-looking snakes, hissing and writhing in the unearthly glare of the abysmal fire.

"At 10 o'clock the scene had reached its climax, but eruptions and earthquake shocks did not cease until 4 o'clock in the afternoon. The landscape then presented a piteous aspect. Within a distance of five miles around the mountain trees and shrubs, as well as all the tea and rice plants—the entire crop of the year—had been destroyed. Forty-four houses were found buried to a depth of twenty feet, and many more were covered to a less depth. Strange to say, few or no small stones were found among the debris; heavy rocks seem to have been numerous; one of them is said to have measured 78 feet in length. The village of Iwase seems to have suffered most, then Yozan and Hibara. Three hamlets near the latter place were covered completely. Not a soul was saved. At Hibara itself the river Nagase was blocked up by fallen debris, and by the sudden rise of a natural bank, 400 feet high and several miles long, across the river's course, obstructing the flow of its waters. Unless the imprisoned river is promptly liberated the entire region will be flooded, and a lake formed where once fine rice fields stood. At Inawashiro and in its neighborhood the people, though not in danger, escaped at the time of the eruption with all their furniture, as though a military invasion had taken place. The people state that the noise as heard there was appalling, resembling the simultaneous discharge of thousands of cannon. As a matter of fact, the lesser peak of Bandai-san has been blown off by the terrific explosion of the subterranean gases and

vapors. On the 19th of July—this is the latest news—another eruption took place, without, however, doing any damage. By it two new craters were formed. Black smoke continues to ascend from the mountain.

"The survivors of the catastrophe were so dazed and bewildered by the sudden disaster that had fallen upon them that most of them were unable to give any coherent account of their escape. One man was, by the first shock, pitched headlong out of his house, and, terrified by this sudden eviction, he ran at once for his life, and never knew what had really happened until after his arrival in Inawashiro. Others had similar experiences; in fact, nobody was likely, under such circumstances, to inquire into what was the matter. Thus far 476 bodies have been recovered. The dismal records speak of fractured skulls, of broken limbs, of faces and bodies battered beyond recognition, of bodies literally cut into halves or quarters, or into still smaller pieces; of bodies actually parboiled by the seething water that fell upon the unsuspecting victims of the eruption. Some bodies were found suspended from the trees into which they had fallen when descending from the air. Harrowing details there are many, but one case, sad and dismal enough, must suffice. A mother with her child tied to her back stumbled onward in hot haste, under a storm of glowing ashes, burning cinders, and falling rocks. A large red-hot stone struck the child and bespattered the mother with blood, without, however, harming her. Holding fast, with a desperate grasp, the red burden on her back, the mother succeeded in reaching Wakamatsu, but only to find that her child was dead.

"The damage done to life and property is not yet exactly known, but it is appalling. The Emperor at once contributed 3,000 yen for the relief of the suffering people, and dispatched a special commissioner to the afflicted region. Through the prompt initiative of Captain Brinkley, of "The Japan Mail," money to be forwarded to the distressed district is now being rapidly collected among the foreign residents here and in Yokohama. The vernacular press is also doing its duty in this direction. The police and local authorities at Wakamatsu have already taken steps to provide for the destitute, some of whom have in very truth saved nothing but their naked life."

FLOWERING TREES AND SHRUBS.

By W. GOLDRING.

PHILADELPHUS (mock orange).—A valuable genus of shrubs commonly represented by the familiar mock orange, or Syringa (Philadelphus coronarius), found in almost every shrubbery. There are a great many kinds, but such a strong similarity exists among them that it is necessary to make a limited selection of the very best. To many the common sort is objectionable on account of the powerful odor of its blossoms, but it is such a vigorous grower and profuse flowerer, that one cannot well do without it. It is well not to plant it too near the house or a walk. Very much finer in every respect are the North American species, which are best represented by P. grandiflorus, P. inodorus, P. speciosus, and P. Gordonianus. These are all of large growth, rising from 6 ft. to 10 ft. in height, forming a rounded mass almost as broad as high. They have all large white flowers in clusters, with little or no scent, produced from midsummer till the end of July. The largest flowered kind is P. grandiflorus, an illustration of which is here given, the blossoms of which are

PHILADELPHUS MICROPHYLLUS (Natural size).

two inches across and of snowy whiteness. Scarcely less beautiful is the variety of it called laxus, on account of its habit of growth and flower clusters being less dense. There is not a finer white flowering shrub in our gardens than this beautiful mock orange, and if there is only room in a garden for one kind, this is certainly the one to plant. The others, though they resemble one another in growth and flowers, are desirable because they flower in succession, and so extend the blooming period. P. inodorus, Gordonianus, and hirsutus are all fine species, and if space will admit, to these may be added the slender growing P. Satzumi from Japan, P. Lewisi from North America, and P. verrucosus, also American. Most of these are procurable in nurseries, but are not invariably known under the names cited; indeed so confused are the names of the mock oranges in nurseries that, with the exception of such as P. coronarius and grandiflorus, one can never be sure of getting the species true to name. There are numerous named varieties of P. coronarius, including one with semi-double flowers called primulæflorus, but it is not desirable, as the doubling of the flowers is not complete. A really ornamental variety is the golden leaved form (follis aureis), whose foliage is of a bright golden yellow tint and particularly bright in early summer. It is a most effective shrub to plant in company with contrasting foliage like that of the purple hazel or purple cherry plum. It should be planted if possible in partial shade, otherwise its foliage is damaged by the hot sun during summer.

An extremely pretty little shrub is P. microphyllus, which is the pygmy of the genus. It has smaller foliage than the myrtle, has slender branches, which in summer are whitened with a profusion of small flowers. It has been recently introduced from New Mexico, and though hardy enough for the south, is perhaps too tender for northern or cold districts. The variegated leaved form of P. coronarius is also an attractive shrub, the variegation being creamy white and deep green.—*The Garden.*

[NATURE.]

THE MICRO-ORGANISMS OF AIR AND WATER.

EVER since the great importance of micro-organisms in the economy of nature was pointed out by Pasteur, now some twenty-five years ago, the presence of these minute living forms in the two great fluid media—air and water—with which we are surrounded has formed the subject of elaborate investigations. As these investigations are thus co-extensive with the period during which micro-organisms have been made the subject of careful study, a review of them becomes particularly instructive as illustrating the gradual development of the methods of bacteriology from the earliest times up to the high degree of perfection to which they have attained at the present day.

It was Pasteur himself who first instituted a systematic inquiry into the presence and distribution of micro-organisms in the atmosphere in connection with his well-known researches disproving the spontaneous generation of life. The experiments which he undertook for this purpose are as remarkable for their extreme simplicity as for the striking results which they yielded. Thus the apparatus with which Pasteur set about exploring the distribution of microbes in the air consisted simply of a number of small flasks, each partially filled with a putrescible liquid such as broth; the necks of these flasks were drawn out and sealed before the blow-pipe while the fluid contents were in active ebullition. The flasks thus prepared were both vacuous and sterile, and could be preserved for an indefinite length of time without the contained liquid undergoing change. A number of these flasks were then momentarily opened in various places—in Paris, in the open country, at various altitudes in the Jura Mountains, and at an elevation of 6,000 feet at the Montanvert, near Chamonix. Each flask on being

PHILADELPHUS GRANDIFLORUS.

PHILADELPHUS HIRSUTUS.

opened became instantly filled with the air of the place in question, while, by sealing the flask directly afterward, the further access of air was prevented. On preserving these flasks which had been thus opened, the liquid of some was found to become turbid and lose its transparency, owing to the development of bacterial life within it, while in others it remained perfectly clear and translucent. It was further observed that the proportion of flasks becoming so affected varied greatly, according to the places where they had been exposed. Thus, of twenty flasks exposed in the open country near Arbois, eight developed living organisms; of twenty opened on the lower heights of the Jura Mountains, five became affected; while of the twenty opened at the Montanvert, close to the Mer de Glace, only one broke down. The proportion of flasks which became affected on being similarly exposed in Paris was considerably greater than in the case of the experiment made at Arbois.

The results of these simple experiments thus convey a most vivid picture of the great density of microbial life in the air of towns, and of its attenuation in the higher regions of the atmosphere, although they can give no account of the *actual* numbers present in the air under examination.

Miquel and Freudenreich * made the first step in the quantitative estimation of aerial microbes by aspirating air through plugs of glass wool, thus taking advantage of a fact long known—that it is impossible for micro-organisms to pass through sufficiently tightly constructed plugs of such materials.

Without entering into a detailed account of this method, the merits and demerits of which have been fully discussed by German investigators, it is sufficient to state that a very large number of experiments have been carried out by the authors which can lay claim to a fair degree of accuracy. However, since solid nourishing media for the cultivation of micro-organisms were introduced by Koch, the importance of substituting the latter for the liquid media hitherto exclusively employed has led experimenters to devise processes which shall render their use possible in the examination of air.

The advantages possessed by solid over fluid media are very great, for whereas in fluid media, such as broth, the organisms are in no way restricted in their movements, and their multiplication can take place indiscriminately throughout the entire liquid, on the other hand, if they are introduced into gelatine-peptone which has been first melted, they can be evenly dispersed throughout the culture material by gentle agitation; and by subsequently allowing it to solidify they are not only isolated, but rigidly confined to one spot. Thus each individual organism becomes a center round which extensive multiplication takes place, and in a few days definite points of growth are visible to the naked eye, which are appropriately described as "colonies," and which can be easily counted with the aid of a low magnifying glass. Although each colony consists of many thousands or even millions of individual microbes, yet, as in the first instance, they owe their origin to a single organism or indivisible group of organisms, it is correct to regard the number of colonies as representing the number of micro-organisms. These colonies have often very beautiful and characteristic appearances,† and it is exceedingly remarkable how constant and distinct for one and the same organism these appearances are. In many cases they give rise to magnificent patches of color—deep orange, chrome yellow, brown, various shades of red, green, black, etc. Often under a low magnifying power they are seen to spread over the surface of the gelatine, producing tangled networks of threads, sometimes they resemble the petals of a flower, sometimes the roots of a tree or its branches; in fact, one is constantly startled by the novelty and beauty of their modes of growth.

Koch ‡ and, later, Hesse § have devised methods by which the organisms in the air become deposited on a solid surface of gelatine-peptone, and by there producing colonies render their estimation possible. A large number of experiments have been made with Hesse's method, which consists in aspirating air through glass tubes about three feet in length, coated internally with a film of gelatine peptone. The organisms, owing to the property they possess of rapidly subsiding in the absence of disturbing influences, fall on the surface of the gelatine and give rise to colonies.

The following series of observations was made by this method in 1886 ‖ on the roof of the Science Schools, South Kensington Museum, in order to trace the seasonal variations in the number of micro-organisms present in the air of one and the same place. The following are the averages obtained for each month during which these observations were made:

Number of Micro-organisms found in Ten Liters (Two Gallons) of Air.

January	4	August	105
March	26	September	43
May	31	October	35
June	54	November	13
July	63	December	20

From these figures it will be seen that it is during the summer that the largest number of micro-organisms are found in the air, while the smallest average number were recorded in the month of January.

The air at sea, the air at higher altitudes, and the air in sewers, have all been explored by means of Hesse's method.

Thus Dr. Fischer, ¶ in experiments carried on at sea, found that beyond a distance of 120 sea miles from land micro-organisms were invariably absent. And, inasmuch as micro-organisms are abundantly present in sea water, it thus appears that no micro-organisms are communicated to the air from the water even when the latter is much disturbed. Moreover, as might have been anticipated, this complete freedom from micro-organisms was attained even in close proximity to land, provided the wind had passed over the above-mentioned distance of sea.

As regards the air at higher altitudes, experiments have been made on the dome of St. Paul's, in London, and on the spire of Norwich Cathedral, which show that even in ascending to such modest elevations in densely populated centers, the number of micro-organisms suspended in the air undergoes very marked diminution.

Thus, on the top of Norwich Cathedral spire, at a height of about 300 feet, I found in ten liters (two gallons) of air only seven micro-organisms, and on the tower, about 180 feet high, I found nine, while at the base of the cathedral, in the close, eighteen were found. These results are fully confirmed by another series of experiments made at St. Paul's Cathedral. In this case the air examined from the Golden Gallery yielded in the same volume eleven, that from the Stone Gallery thirty-four, while in the churchyard there were seventy micro-organisms present.

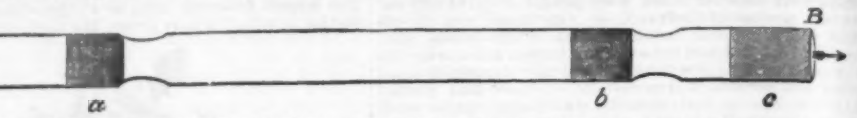


FIG. 1.—GLASS TUBE THROUGH WHICH THE AIR IS ASPIRATED. (About the original size.)

A, aperture of tube through which the aspirated air enters; B, exit of aspirated air; *a*, first filter plug, consisting of glass-wool; *b*, second filter plug, consisting of glass-wool and powdered glass or sugar; *c*, cotton-wool plug to protect plug *b*.

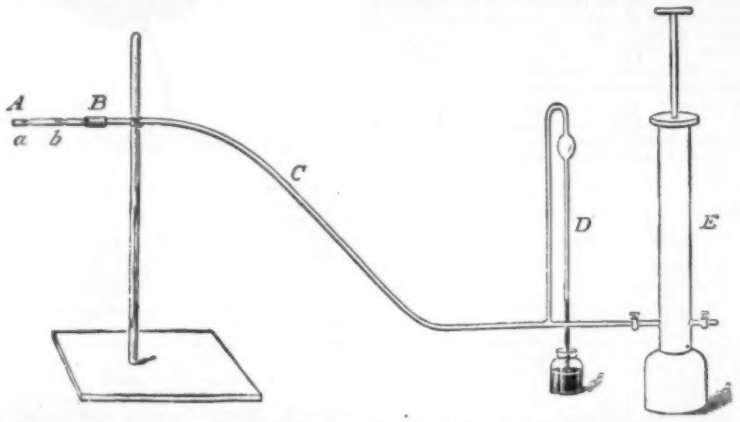


FIG. 2.—ARRANGEMENT OF THE APPARATUS FOR TAKING A SAMPLE OF AIR.

A, B, the filter tube; C, lead tubing, about 10 feet in length; D, mercury pressure gauge; E, air pump.

The contrast between town and country air, and even between the air of the London parks and streets, is also exceedingly sharp. In Hyde Park—the place selected for the experiment being as far removed from roads and traffic as possible—I found eighteen, while on the same day, June 7, the air in the Exhibition Road, South Kensington, yielded as many as ninety-four. On the following day, however, when the traffic was very great, and the air was consequently heavily laden with dust, the number rose to 554. This is in marked contrast to the microbial condition of country air, for on the Surrey Downs in the same volume only two micro-organisms were found; and in the case of an extensive heath near Norwich, only seven.

Within doors we find that the number of micro-organisms suspended in the air depends, as we should have expected, upon the number of people present, and the amount of disturbance of the air which is taking place. Thus, on examining the air in the large entrance hall of the Natural History Museum in Cromwell Road, it was found to yield under ordinary conditions from fifty to seventy organisms in the same volume (two gallons), but on Whit-Monday, when an immense number of visitors were present in the building, I found as many as 280. Again, on a paying day at the South Kensington Museum, about eighteen micro-organisms were found, but on Saturday, when no entrance fee is charged, there were as many as seventy-three in the same volume of air.

The air of sewers has been shown by Carnelley in this country, and by Petri in Berlin, to be remarkably free from micro-organisms, the number being almost invariably less than in outside air. That this should be the case is only natural when the moist nature of the walls and the absence of dust in these subterranean channels is borne in mind; and although their liquid contents is teeming with bacterial life, there is no reason why the latter should be carried into the air, provided no effervescence or splashing takes place. On the other hand, if the contents of a sewer enter into fermentation, and bubbles of gas become disengaged, minute particles of liquid with the living matter present may be carried to great distances, and it must not, therefore, be too hastily concluded that because sewer air is generally remarkably free from micro-organisms, therefore a visit to the sewers should be attended with such beneficial results as a trip to sea or the ascent of a mountain summit!

During the use of Hesse's method I became acquainted with several serious defects which it possessed, and in order to overcome these disadvantages I was led to devise a new process * for the examination of air. This consists essentially in aspirating a given volume of air through a small glass tube, not more than 4 inches long and ¼ inch in width, which is provided with two filter plugs, the first of which is more pervious than the second, and consists of glass wool coated with sugar, while the second contains, in addition, a layer,

FIG. 3.—FLASKS AFTER INCUBATION, SHOWING COLONIES ON FILM OF GELATINE WITH WHICH THE INNER SURFACE IS COATED.

¼ inch in thickness, of fine sugar powder. On these plugs the microbes suspended in the aspirated air are deposited, and each of these plugs is then introduced into a separate flask containing a small quantity of melted gelatine-peptone; with this the plug is agitated until it becomes completely disintegrated, and since the sugar coating of the glass wool dissolves in the liquid gelatine, the microbes become immediately

* "Annuaire de l'Observatoire de Montsouris," 1879–85.

† "Studies on Some New Micro-organisms obtained from Air," Phil. Trans., vol. clxxviii. p. 257.

‡ *Mittheilungen aus dem kaiserlichen Gesundheitsamte*, 1881, Bd. i.

§ *Ibid.*, 1883, Bd. ii.

‖ "The Distribution of Micro-organisms in Air," Proc. Roy. Soc., No. 245, 1885; "Further Experiments on the Distribution of Micro-organisms in Air," Proc. Roy. Soc., vol. xlii., p. 207, 1886.

¶ "Bacteriologische Untersuchungen auf einer Reise nach Westindien," *Zeitschrift fur Hygiene*, Bd. i., Heft 2.

* "A New Method for the Quantitative Estimation of the Micro-organisms Present in the Atmosphere," *Phil. Trans.*, vol. clxxviii., p. 113.

detached. The contents of the flask are then made to congeal in the form of a thin film over its inner surface. The flasks are then preserved at a suitable temperature, and in the course of a few days the colonies derived from the organisms, which were collected by the plug, make their appearance and can be counted and further studied. Now, if the plug has been properly constructed, the flask into which the second or more impervious plug has been introduced will be found to remain quite sterile, clearly showing that the first plug has arrested all the microbes suspended in the aspirated air. This method yields results which agree not only very closely among themselves, but also with those obtained by Hesse's method, if the experiments are made in still air, which is the condition necessary for an accurate result being obtained with a Hesse tube. As this new method is equally applicable in disturbed air, it possesses great advantages over Hesse's, and is, moreover, considerably more convenient, as it renders possible the examination of a far larger volume of air in a very much shorter space of time, the apparatus required being also exceedingly portable.

Of the presence of pathogenic or disease-producing micro-organisms in air, there is little or no direct evidence so far; it must, however, be remembered that it is just in the case of those extremely infectious diseases, such as measles, whooping cough, etc., in which the virus might be expected to be carried through the air, that the exciting organized poisons have not yet been discovered and identified.

The investigations on aerial microbia, so far as they have as yet been carried, are of service in indicating how we may escape from all micro-organisms, whether harmful or harmless; and secondly, how we may avoid the conveyance of micro-organisms into the atmosphere from places where pathogenic forms are known or likely to be present. This acquaintance with the distribution of micro-organisms in general, and the power of controlling their dissemination which it confers, is really of far wider practical importance than discovering whether some particular pathogenic form is present in some particular sample of air. It is this knowledge which has led to the vast improvements in the construction and arrangement of hospital wards and of sick rooms generally, and which has directed attention to the importance of avoiding all circumstances tending to disturb and distribute dust.* It is, moreover, this knowledge of the distribution of micro-organisms in our surroundings which has formed one of the foundations for the antiseptic treatment of wounds—that great step in surgery with which the name of Sir Joseph Lister is associated.

Micro-organisms in Water.

The micro-organisms present in water have long been studied by direct observation with the microscope. Such observations can, however, only be made in the case of foul waters, in which bacterial life is very abundant, and even in such cases the information gained by the microscope alone has but little value. It is to the modern methods of cultivation, more especially those in which solid media are employed, that our increased knowledge concerning these primitive inhabitants of water is due. Thus the beautiful process of plate cultivation introduced by Koch,† and to which more than to anything else the recent advances in bacteriology are due, has been of the greatest service in the investigation of a number of questions bearing on the micro-organisms in water. The method of plate cultivation consists, as is well known, in taking some of the liquid or other substance under examination for micro-organisms and mixing it with melted gelatine peptone in a test tube, the mixture being then poured out on a horizontal plate of glass and allowed to congeal, the plate being then preserved in a damp chamber at a suitable temperature. In the course of a few days colonies make their appearance in the gelatine film, and can be counted and further studied as required. This process is of extremely wide application, for by this means pure cultivations of the various organisms in a mixture can be readily obtained. If a definite volume of water be submitted to this method of plate cultivation, the resulting colonies on the plate clearly indicate both the number and the character of the organisms present in it.

From numerous investigations made by means of gelatine plate cultivations, it appears that while surface waters, such as rivers, contain an abundance of microbial life, waters which, like those from springs and deep wells, have undergone filtration through porous strata contain but very few micro-organisms. Now, since such underground waters have at some time or other been surface waters, it is obvious that in passing through the porous strata of the earth they have been deprived of those microbes which they contained while at the surface. This removal of micro-organisms from water‡ also takes place in a very marked manner when it is submitted to some kinds of artificial filtration, such as that through very finely divided coke or charcoal, as well as in the filtration of water on the large scale through sand. The process of filtration, however, which absolutely removes microbes with the greatest degree of certainty is that introduced by Pasteur, in which the water is forced through porous porcelain. It is especially noticeable that the efficiency exhibited by these various materials in removing micro-organisms stands in no sort of relationship to their chemical activity, *i. e.*, power of removing organic matter from water. Thus the porous porcelain produces practically no change whatever in the chemical composition of the water, while it deprives it entirely of micro-organisms.

The relative abundance of bacterial life in surface water, in deep well water, as well as in surface water after filtration through sand on the large scale, is well illustrated by the following results.

Thus the average number of micro-organisms obtained during the past year from a cubic centimeter (about twenty drops) of the raw water as abstracted from the rivers Thames and Lea by the metropolitan water companies was 21,500 and 13,200 respectively. The same water, however, after having undergone storage and filtration contained on an average respectively 500 and 450 micro-organisms in one cubic centimeter. It is at once apparent, therefore, what striking results can be obtained by sand filtration as at present carried out, and there is no doubt that with the introduction of fresh improvements and increased care an even greater reduction will be effected.

In deep well water obtained from the chalk, which has undergome no artificial filtration, we find the remarkably low number of eighteen as the average for the year. Thus the artificial filtration through sand is far surpassed by the exhaustive filtration through vast thicknesses of porous strata.

Another point which has been brought to light through investigating the micro-organisms of water by means of the improved methods which we now possess is that many of the microbes found in natural waters are capable of the most abundant multiplication* in the absence of practically any organic matter whatever. Thus, if the deep well water referred to above is preserved for several days thoroughly protected from contamination through the air, and is then examined for micro-organisms, it will be found that these have undergone an enormous increase, one cubic centimeter containing many thousands instead of the ten or twenty usually present in the water at the time of pumping. It has been found, moreover, that some of the water organisms are even capable of such abundant multiplication in water which has been several times redistilled, and which is, therefore, almost absolutely pure. From what source such organisms obtain their necessary nourishment under these circumstances has not yet been determined. The following figures serve to illustrate the extent to which multiplication of this kind may take place:

Number of Micro-organisms obtained from one Cubic Centimeter of Water.

	Day of Collection.	Standing 1 day at 20° C.	Standing 3 days at 20° C.
Sample of water from Kent Co.'s deep well in chalk.....	7	21	495,000

It is often urged that the bacteriological examination of water is of little practical importance, inasmuch as the micro-organisms found are not necessarily prejudicial to health, and that the method of examination does not aim at the detection of harmful forms. A little more mature consideration, however, will show that the actual detection of harmful or pathogenic forms is a matter of very little importance, and that if methods of water purification are successful in removing micro-organisms in general, and more especially those which find a suitable home in natural waters, there can be no serious doubt that they will be equally successful in removing harmful forms which are not specially adapted for life in water. Could it be, for instance, reasonably contested that a method of purification which is capable of removing the *bacillus aquatilis* from water would be incapable of disposing of the *bacillus anthracis* when suspended in the same medium? The supposition is, on the face of it, absurd, and not a particle of experimental evidence can be adduced in its favor. It is, therefore, only rational to conclude that those methods of water purification, both natural and artificial, which succeed in most reducing the total number of micro-organisms will also succeed in most reducing the number of harmful forms should they be present.

As a matter of fact, however, pathogenic forms can and have been discovered in waters by the process of plate cultivation; thus the "comma bacillus," which is by many authorities regarded as the cause of Asiatic cholera, was found by Koch in some tank water in India, and the bacillus which with more or less probability is identified with typhoid fever has by Chantemesse and Widal been discovered in the drinking water which had been consumed by persons suffering from that disease.

On the other hand, the examination of water for the number of micro-organisms present can have no value if the multiplication referred to above has taken place. Thus, if the number of micro-organisms present in a water is to throw light on the natural purification it has undergone, the sample for examination must be taken as near as possible to the point where it issues from the water-bearing stratum, and, in the case of artificially purified water, as soon as possible after it has left the purifying apparatus.

Of much more importance than the discovery of pathogenic organisms in particular waters is the problem of ascertaining the fate of pathogenic forms, when these are introduced into waters of different kinds. A considerable amount of work has been done in this direction with a number of typical pathogenic forms,† and some very remarkable results have been obtained. Thus it has been found that the bacilli of anthrax do not survive many hours on being introduced into ordinary drinking water; their spores, however, are not in any way affected by such immersion, and even in distilled water the latter retain their vitality for practically an indefinite length of time. In polluted water, such as sewage, on the other hand, not only do the bacilli not succumb, but they undergo extensive multiplication. Similarly, Koch's "comma bacillus" was found to flourish in sewage, being still present in very large numbers after eleven months' residence in this medium. In deep well and filtered Thames water, on the other hand, although the "comma bacilli" were still demonstrable after nine days, they were only present in small numbers. Much less vitality is exhibited by the micrococcus of erysipelas when introduced into waters of various kinds, for even in sewage this organism was not demonstrable on the fifth day. In fact all the pathogenic micrococci which have been experimented with in this manner exhibit but little vitality under similar circumstances.

From these experiments it appears, therefore, that while ordinary drinking water does not form a suitable medium for the extensive growth and multiplication of those pathogenic forms which have hitherto been made the subject of investigation in this respect, yet that in the condition of spores they are extremely permanent in any kind of water, however pure, and that even those of which no spores are known may often be preserved for days or even weeks.

Thus the investigations which have hitherto been made on the micro-organisms both of air and water, by the light which they throw on the behavior of micro-organisms in general in these media, the manner in which they may be preserved and the manner in which they may be removed, are of great service in indicating how the spread of zymotic diseases through these media is to be avoided.

Until we are fully acquainted with all pathogenic forms of microbes, a consummation which is certainly not likely to be attained in the near future, it is obvious that in endeavoring to exclude dangerous organisms we must attempt to exclude *all* organisms, *e. g.*, in the purification of water which has been exposed to possibly noxious pollution, that process of purification which insures the removal or destruction of the greatest proportion of micro-organisms must be regarded as the most efficient. In just the same way as in the antiseptic treatment of wounds, the preventive measures employed by surgeons are of such a nature as to destroy or preclude the possibility of growth of *any* microbes whatever, and not only of those known to be capable of causing mischief.

PERCY F. FRANKLAND.

THE CHEMICAL CONSTITUTION OF PEARLS.*

By GEORGE HARLEY, M.D., F.R.S., and HARALD S. HARLEY.

ALTHOUGH there are many qualitative analyses of pearls, from our being unable, in their voluminous literature, to find any evidence of a quantitative analysis of their ingredients having been recorded, we undertook the examination of several varieties, of which the following is an account:

1st. As regards oyster pearls. Of these, three varieties were examined, British, Australian, and Ceylonese.

The qualitative analyses showed that they all had an identical composition, and that they consisted solely of water, organic matter, and calcium carbonate. There was a total absence of magnesia and of all the other mineral ingredients of sea water—from which the inorganic part of pearls must of course be obtained. Seeing that ordinary sea water contains close upon ten and a half times more calcium sulphate than calcium carbonate, one might have expected that at least some sulphates would have been found along with the carbonates, more especially if they are the mere fortuitous concretions some persons imagine them to be—a view we cannot indorse, from the fact that by steeping pearls in a weak aqueous solution of nitric acid, we are able to completely remove from them all their mineral constituents without in any way altering their shape, and but very slightly changing their naked eye appearances, so long as they are permitted to remain in the solution. When taken out they rapidly dry and shrivel up. We shall take occasion to point out in our next communication, which will be on the microscopic structure of pearls, that a decalcified crystalline pearl bears an intimate resemblance to a decalcified bone, in so far as it possesses a perfectly organized matrix of animal matter. No phosphates whatever were found in any of the three before named varieties of pearls.†

The next point being to ascertain the exact proportions of the substances composing the pearls, and pure white pearls being expensive, from our having ascertained that all the three kinds we were operating upon had exactly the same chemical composition, instead of making separate quantitative analyses of them we simply selected two pearls from each variety, of as nearly the same size and weight—giving a total of 16 grains—and analyzed them collectively, the result obtained being:

	Per cent.
Carbonate of lime‡.....	91·72
Organic matter (animal)	5·94
Water.....	2·23
Loss.....	0·11
	100·00

From this it is seen that notwithstanding that mother of pearl consists of precisely the same ingredients, their proportions are quite different from what they are in fine pure white pearls (we say fine pure white, because pearls vary greatly in purity, and those we analyzed were good ones), which are infinitely denser, and consequently harder, than the mother of pearl constituting the shells in which they are formed. The analysis of mother of pearl given in Watts' "Dictionary of Chemistry" is—

	Per cent.
Carbonate of lime.....	66·00
Water	31·00
Organic matter.....	3·50

Thus showing that while mother of pearl contains less than half the quantity of organic matter pearls do, it at the same time possesses close upon fourteen times more water. This fact appears to us all the more surprising as, not alone to the naked eye, but even under the microscope, the structure of the mother of pearl of the shell and of pearls is almost identical.

[One can scarcely imagine that the analyst could have possibly employed in his investigation a piece of shell while it was yet in a fresh and consequently moist state.]

As regards the hardness of pearls, again, it may perhaps be as well for us to remark that good pearls have a much denser texture than the majority of persons appear to suppose, as may be gleaned from the following facts.

On one occasion, being desirous to crush into powder a split-pea sized pearl, we folded it between two piles of note paper, turned up the corner of the carpet and placing it on the hard bare floor, stood upon it with all our weight. Yet notwithstanding that we weigh over twelve stone, we failed to make any impression what-

---

* *Mittheilungen aus dem kaiserlichen Gesundheitsamte*, Bd. i., 1881.

† "The removal of micro-organisms from water," Proc. Roy. Soc., No. 239, 1885.

* On the multiplication of micro-organisms," Proc. Roy. Soc., No. 245, 1886. "Ueber das Verhalten verschied. Bacterienarten im Trinkwasser," Meade Bolton, *Zeitschrift fur Hygiene*, Bd. i., Heft 1.

† "Die Vermehrung der Bacterien im Wasser," Wolffhügel und Riedel, *Arbeiten a. d. kaiserlichen Gesundheitsamte*. "Ueber das Verhalten, etc," Meade Bolton. "On the multiplication of micro-organisms," Proc. Roy. Soc.; also "Recent bacteriological research in connection with water supply," Soc. Chem. Ind., vol. vi., No. 5.

* Read before the Royal Society, on March 11. From the "Proceedings."

† Phosphates are referred to as being present in pearls by Rudler in his article in the "Encyclopædia Britannica."

‡ The carbonic acid was estimated by disengaging it with dilute sulphuric acid into a soda lime tube, and calculating the increase in weight (as described by Lange and Hurter in "The Alkali Maker's Pocket Book"). The amount of the organic matter by noting the loss by weight after calcining—slightly moistening the mass with a solution of ammonium carbonate.

ever upon the pearl, and even stamping upon it with the heel of our boot did not suffice so much as to fracture it. It was accordingly given to the servant to break with a hammer, and on his return he informed us that on attempting to break it with the hammer against the pantry table, all he succeeded in doing was to make the pearl pierce through the paper and sink into the wooden table, just as if it had been the top part of an iron nail, and that it was not until he had given it a hard blow with the hammer against the bottom of a flat iron that he succeeded in breaking it.

[In addition to the foregoing, we may likewise take occasion to mention that shell fish pearls are not nearly so easily dissolved in strong vinegar as the interesting tale of Cleopatra having taken a large pearl from her ear, and after having dissolved it in vinegar, drunk it to the health of her lover Antony, would lead one to believe. For during our experiments we have learned that not only does it take many days to dissolve out the mineral constituents of a large pearl in cold vinegar, but that it even requires several hours to extract the mineral matter, by boiling vinegar, from a pearl not bigger than a garden pea. While in neither case, moreover, can the pearl be thus made to disappear, as, from the fact of the organic matrix of a pearl being totally insoluble in vinegar, even after every particle of its earthy substance has been removed, it still remains of the same shape, bulk, and almost identical appearance as before. Hence we fear that if the Cleopatra legend is to be believed at all, it requires considerable modifications ere it can be brought into harmony with scientific truth. There is, indeed, only one way in which a large pearl, such as the one Cleopatra is said to have employed, could be dissolved in vinegar at a supper table, and that is by having it completely pulverized by a hard hammer and a strong arm before applying the vinegar to it. For once the mineral constituents of a pearl have been reduced to the state of an impalpable powder, they not only readily dissolve, but effervesce like a Seidlitz powder—though much less strongly—when brought into contact with strong vinegar, and thus on their being diluted with water may be transformed into what might be called a cooling lover's potion, while from the organic matter having at the same time as the mineral constituents been minutely subdivided, its presence would scarcely be recognizable in the solution.]*

3d. Composition of cocoa nut pearls.

Qualitative analyses of pearls found in cocoa nuts have been published by both Dr. J. Bacon and Dr. Kimminis.† But their analyses differ somewhat, for while Bacon found carbonate of lime and an organic substance akin to albumen, Kimminis met with nothing whatever in them except pure carbonate of lime. We subjected a portion of a garden pea sized cocoa nut pearl weighing 14 grains (kindly given to us by Messrs. Streeter) to analysis, and found that, like shell fish pearls, it consisted of carbonate lime, organic matter (animal), and water.

The pearl which we examined was sent to Messrs. Streeter by their agent at Singapore (the same place from whence Bacon obtained his specimen), and as we stated last year (on June 8), when we exhibited at the *soiree* of the Royal Society both drawings and microscopic sections of it, we are exceedingly skeptical of the pearl we examined being in reality the product of a cocoa nut, for the following reasons. It had all the external appearances of the pearls found in the large clams (*Tridacna gigas*) of the Southern Ocean, being perfectly globular, with a smooth, glistening, dull white surface, and resembling them exactly in microscopic structure. Besides which in chemical composition it bore no similarity to cocoa nut milk, to which it is supposed to be related. For cocoa nut milk is said to contain both the phosphate and the malate, but not the carbonate of lime. That there are pearls found in cocoa nuts we do not presume to deny; all we mean to say is that we are doubtful if the specimen we examined had such an origin.‡

3d. As regards mammalian pearls.

These so-called pearls have been met with in human beings and in oxen. The first person who kindly called our attention to those of the ox was the late Professor Pannum, of Copenhagen, who in 1874 presented us with some specimens he had found in the gall bladder of a Danish ox.

In so far as naked eye appearances are concerned, a good specimen of the variety of pearl now spoken of is quite undistinguishable from a fine specimen of oriental oyster pearl, from its not only being globular in shape, and of a pure white color, but from its also possessing the iridescent sheen so characteristic of oriental oyster pearls of fine quality.

In chemical composition, however, mammalian pearls bear no similarity whatever to pearls found in shell fish, for they are composed of an organic instead of an inorganic material, namely cholesterin. In minute structure, again, they bear a marked resemblance to the crystalline variety of shell fish pearls.

The quantitative analysis of human pearls yielded in 100 parts—

Water	2·05
Solids	97·95

The solids consisted of—

Cholesterin.....	98·63
Animal matter.....	1·37

From this it is seen that human pearls are in reality nothing more nor less than exceedingly pure cholesterin biliary concretions.

This note on the chemical composition of pearls is intended as a prelude to a paper we purpose shortly laying before the society on the microscopic structure of the different varieties of pearls we had the honor of exhibiting sections of with the lime light, as well as microscopic drawings, at the *soires* on June 8, 1887, and of which a detailed report was given in No. 17 of the *Cheltenham Ladies' College Magazine*, pp. 37-42, by J. F. Muspratt.

* Added March 27, 1888.

† See "Proceedings of the Boston Society of Natural History," vol. vii., 1861, p. 250; vol. viii., 1862, p. 173; *The Tropical Agriculturist*, April, 1887; and *Nature*, June 16, 1887 (Dr. Hickson and Mr. Thiselton Dyer).

‡ Since this paper was in type I have kindly had my attention drawn by Dr. Hickson to a letter from J. G. F. Riedel, of Utrecht, in *Nature*, September 15, 1887, in which he states that in 1886, while in the North Celebes, he found a pearl "in the endosperm of the seed of the cocoanut." And that he has in his possession "two melati pearls (*Jasminium sambac*); one tjampaka pearl (*Michelia longifolia*), found in the flowers, according to the natives. One of the cocoa nut pearls has a pear shaped form, the length being 28 mm. The common name among the natives for this kind of pearl is mustika."—G. H., March 1, 1888.

SOME PHASES IN THE PROGRESS OF CHEMISTRY.*

SINCE the isolation of oxygen by Priestley, the search for new elements has been carried on vigorously, and the facilities for this pursuit have been much increased by the use of the delicate spectroscopic methods. The result has been to continually extend the list of bodies which are grouped under this head. The announcement of new discoveries during the last ten years has been especially large, over seventy bodies having been added to the list during this time. The largest number added by any observer has resulted from the joint labors of Kruss and Nilson on the absorption spectra of the rare earths, and reaches to over twenty. Should these discoveries be verified, the possible number of compounds which would result is something enormous, but, judging from experience, few are likely to survive a very searching inspection; yet one of them, "germanium," discovered by Winkler in 1886, has already been accepted as one of the missing elements in Mendelejeff's scheme, whose existence and properties he predicted.

Since the unit weight of hydrogen is taken as the standard for comparison, while the determination of the atomic weights of a large number of the elements has been made only through the intervention of oxygen, the ratio of the atomic weights of these two elements is the most important one to be determined, and many attempts have been made to solve this problem. The older experiments of Dumas and others were recently subjected to a careful scrutiny, and it was shown that they were not sufficiently exact. As the determination of atomic weights is of the greatest importance for the validity of the modern theories of chemistry, many experimenters of the greatest skill devoted themselves to researches on this subject, and, by means of improved methods, results of great accuracy were obtained. All these researches are of great intrinsic value and interest; but nevertheless they show that even yet, with all the advantages of purity of material, perfection of apparatus, and precision of methods, united to great skill and extensive attainments on the part of the experimenter, the attractive hypothesis of Prout remains experimentally unproved. Many hold that the failure in the proof has been due to constant errors in the experimental processes; but Meyer and Seubert, from an elaborate discussion of the determinations of the atomic weight of silver and of those of the other more important elements calculated by its means, declare that they all contradict Prout's hypothesis in its characteristic original conception, and that it must therefore be looked upon as having been disproved by experiments.

Crookes suggests a hypothesis which may account for certain of the discrepancies in the atomic weight determinations without resorting to the supposition of constant errors. He supposes that elements, instead of being composed of parts of matter which are identical throughout, are really composed of groups of particles which are only approximately alike, and whose weights only approximate to that average which we call the atomic weight. Hence it is possible that in different portions of such congeries different average values within small limits may obtain. Still it is remarkable that such close coincidences should result as have resulted from the observations made on material obtained from widely separated sources.

The determination of molecular weights is of nearly equal importance with that of the weights of the atoms. Thanks to Avogadro's law, we are able, when the substance can be obtained in the gaseous state, to determine its true molecular formula. When, however, the body cannot be completely volatilized unchanged, we have until recently been dependent upon isomorphism and the laws of molecular volumes and of specific heats, and upon analogical comparisons, to furnish us with estimates of the molecular weights. A new method of determining these weights was discovered by Raoult, who deduced a formula from the depression of the freezing point of solutions. He showed that by knowing the weights of the substance dissolved and of the solvent, and by knowing the depression of the freezing point, the molecular weight may be calculated. He has examined a large number of substances whose molecular weights had previously been determined by their vapor densities, and the results obtained illustrate in a remarkable manner the accuracy and general application of this new method.

There has long existed a conviction in the minds of chemists that the molecular constitution of bodies in the solid state was much more complex than in the gaseous, owing to polymerization; and the opinion finds support in the diminishing density and increasing molecular simplicity of such bodies as acetic acid and sulphur when subjected to high temperatures. By analogy this aggregation of molecules should proceed as we pass from the gaseous through the liquid to the solid state. Is it not, then, singular that the molecular weights derived from Raouit's method for bodies in a state of solution should be identical, or approximately so, with those deduced from their densities in the state of a gas? This method fails to afford any indication whatever of this molecular complexity in solids and liquids. Must it not, then, be assumed that the solvent has effected the complete dissociation of the complex molecules present in it? If so, this probably extends to all cases of true solution without chemical action, if such there be; and this is assumed in this method, for, although the solvent used has been varied, it has given similar results.

Until recently we have known little precisely about the nature of solution. It has been held by some to differ essentially from chemical combination, but no satisfactory solution was offered until Mendelejeff made his important researches on this subject. He says, solutions may be regarded as strictly definite, atomic chemical combinations at temperatures higher than their dissociation temperature. Definite chemical substances may be either formed or decomposed at temperatures which are higher than those at which dissociation commences. The same phenomenon occurs in solutions. At ordinary temperatures they can be either formed or decomposed. In addition, the equilibrium between the quantity of the definite compound and of its products of dissociation is defined by the laws of chemical equilibrium, which laws require a relation between equal volumes and their dependence on the mass of the active component parts. Therefore, if the above hypothesis of solution be correct, comparisons must be made of equal volumes. The specific gravities are the weights of equal volumes; and, moreover, we must expect the specific gravities of solutions to depend on the extent to which the active substances are produced: therefore the expression for specific gravity, s, as a function of the percentage composition, p, must be a parabola of the second order, while between two definite compounds which exist in solutions we must expect that the differential coefficient $\frac{ds}{dp}$ will be a rectilinear function of p.

This theory has been proved by experiment, and not a single case was found in which it did not hold good. Later on, Crompton and Mendelejeff extended this theory to the discussion of electric conductivity of aqueous solutions, and the results have been very encouraging, being entirely in favor of Mendelejeff's theory of solution. Thus it is shown that even this seemingly simple process is very complex, and it is in the study of such processes that probably the most important progress in the theory of chemical processes will be made. This study will lead us to a clearer understanding of the properties of matter.

The evidence supplied by the various branches of chemistry has forced the conviction in the minds of many of the ablest chemists that all matter is one, and varies only as it is acted upon by force; while on the other hand, the transformations of energy which are continually to be seen occurring in nature and in art as continually prove the truth of that glorious conception, the doctrine of the conservation of energy, and equally force the conviction that all energy is one, and varies only in its manifestations.

The belief in the unity of matter is as old as philosophy, and, as has been said, this belief has in recent times been strengthened to conviction by the development of such facts as I have alluded to above; and this conviction has been supported by the more recently discovered evidence that the properties of the elements are functions of their atomic weights, and that the elements, when arranged according to their atomic weights, fall into natural and periodic groups; for it is a fundamental deduction from the law of periodicity, that the various elementary atoms must be aggregations or condensations of one and the same primordial substance. Strong as the conviction resting upon this evidence may be, there is yet lacking the crucial proof; for we have as yet failed to observe the passage of matter from the form of one elementary substance to that of another, or the resolution of any element into or its creation from primordial matter.

The case for the evolution of the elements from periodical matter has been very ably summed up by Crookes while in addition he has brought forward experimental proof of the possible existence of bodies which, though neither compounds nor mixtures, are not elements in the strictest sense of the word. These bodies, which he styles "meta-elements," consist of different groups, which shade off so imperceptibly, the one into the other, that it is impossible to erect a definite boundary between any two adjacent bodies, and to say that the body on this side of the line is an element, while the one on the other side is non-elementary. Yet by means of fractionation these bodies may be separated one from the other, and then they exhibit slight spectral differences.

Finally, Grunwald has announced that during a mathematical investigation of the changes which the properties, and especially the spectra, of two bodies undergo when they unite to form a new substance, he discovered a simple and important proposition of a future chemico-mathematical theory of perturbations; and by its means he has shown the compound nature of hydrogen and oxygen, and has demonstrated the dissociation of hydrogen in the sun. The method employed is a spectral one, and requires conditions which cannot be reproduced at the will of man; so that if it stands the tests of criticism, which is doubtful, it will not then enable us to witness the evolutionary process in actual operation.

Hence we find for the doctrine of evolution in the domain of chemistry, that the tests yield absolute results when applied to compound matter; but the extension of the doctrine to the genesis of the elements is a pure speculation, and bids fair at present to be incapable of absolute proof.

* Abstract of an address before the Section of Chemistry of the American Association for the Advancement of Science at Cleveland, O., Aug. 15-22, 1888, by C. E. Munroe, vice-president of the section.—*Science*.

MAIZE OR CORN OIL.*

By J. U. LLOYD.

IT is well known that Indian corn contains considerable quantities of fixed oil, and, some years ago, endeavors were made to separate this oil on a large scale from the ground corn before it was mashed in the making of whisky. The writer remembers that the late John Crawford, well known as a Cincinnati pharmacist, embarked in a venture with this object in view, and established a factory in Kentucky opposite the city of Cincinnati for the purpose of making bisulphide of carbon, which was used as a solvent to dissolve the oil. The corn meal was percolated with this bisulphide of carbon, whereby the fixed oil was removed, and the bisulphide of carbon was afterward recovered by distillation.

It was thought by Mr. Crawford that the corn meal so treated yielded a larger amount of whisky and of finer quality than when the crude meal was worked. However, after devoting some years to this industry and establishing the process in several sections of the country in connection with distilleries, it was found, I think, that objections rendered it impracticable, and that the advantages derived from the process were more than overcome by the disadvantages that followed. In consequence, if I remember correctly, even before Mr. Crawford's death, the scheme was dropped and the industry abandoned.

It has been found in the making of starch; and per-

* Paper read at the annual meeting of the Ohio Pharm. Association, at Columbus.

haps in other directions as well, that it is desirable to get rid of the germ of the corn, as, for reasons that it is unnecessary for me to mention, this germ is objectionable in these manipulations.

In order to accomplish this result, a machine has been devised which degerminizes the corn, throwing the hard starchy part of the corn in one direction and separating the germs in another, and this method can be and is applied to the making of starch in large quantities, and is found to be of great assistance and advantage.

Naturally, there was an accumulation of these excluded germs, which, as is well known, constitute a considerable proportion of the corn, and they became a by-product. They were found to be valuable as a feed for stock, but really were too rich for such purposes, containing as they did such an enormous quantity of oil, the oil of the corn being altogether found in the germ. In order to render the material more acceptable as a feed for stock, a company was recently established for the purpose of squeezing the fixed oil from germs and thus improving the feed meal. A plant was established a few months ago (the only one in existence now, I learn) in the city of Cincinnati for this purpose and is now in operation. The method is very simple. The germs are conveyed from the factories, wherein they are a by-product (such as starch factories), and are first purified by separating from them a considerable amount of bran or husk of corn that adheres to them or is mixed with them. They are then steamed under pressure so as to soften them, after which, in the usual manner, by means of hydraulic presses, the oil is squeezed from them.

The process is a very simple one and it yields an oil cake which, when ground into meal, is found to be exceedingly valuable as a food for stock, the manufacturers of this meal claiming that it is superior to corn meal that is made from the whole corn.

Thus it is that in addition to the oil cake, which is the prime object of the industries, there is an accumulation of the fixed oil of corn or maize oil, which induces this paper. I accidentally came across the oil, was led to its examination, and as a result found that it is in many respects preferable, as I believe, to cotton seed oil, that has recently become officinal in the pharmacopœia as a substitute for olive oil. I have used it in the making of ammonia liniment, to which purpose it is particularly adapted, and in which, to my experience, cotton seed oil is practically a failure.

Oil of corn saponifies *immediately*, forming with ammonia a smooth, creamy emulsion that retains its nature apparently indefinitely, as specimens that I have in my possession, and which I herewith exhibit, are quite old and are now in their original condition. It does not clot and form masses or curd-like aggregations, as we sometimes find to result with olive oil, in accordance with the manner in which the ammonia is added to it, and even if for no other use than the making of ammonia liniment, I think it should become officinal instead of cotton seed oil. However, I doubt if there is any preparation in the pharmacopœia that demands olive or cotton seed oil in which it cannot be used, and probably it will be found superior in all other directions. The industry that yields this oil, in course of time, promises to increase, and the oil will likely be obtained in unlimited amounts. Indeed, it can now be obtained in any quantity, car load or otherwise. It is not probable that the output will ever be less than the demand. It is peculiarly, and of necessity, an American production, and will always probably be at our command.

The price is reasonable, in car loads being now forty cents per gallon. Of course, in smaller quantities, as it will be obtained by the retail druggists, there will be an increase probably reaching to sixty cents; but even if the price should be equal to that of cotton seed oil, or a little above it, so far as I am concerned, I say that it has proved in my hands enough superior to cotton seed oil, for the making of volatile liniment (wherein I suggest its employment), to merit a better price.

Properties.—Maize oil has been analyzed by an English chemist, and the well known authority, Prof. Chas. O. Curtman, M.D., of St. Louis, has determined its character as follows:

"Oil from embryo of Indian corn, in unrefined state, has a specific gravity of 0·916 at 15° C., which is nearly that of pure olive oil (0·915 to 0·918).

"The elaidine test shows the presence of a large quantity of oleine, intermediate in quantity between olive and cotton seed oils.

"Its color is a pale yellowish brown; its odor and taste that of freshly ground corn meal.

"It belongs to the non-drying group of the vegetable oils, experiments showing that a very thin layer on paper does not in three weeks' time form a pellicle on the surface exposed to air. In this respect it closely resembles the oils of olive, almond, colza, rape seed, etc.

"It does not very rapidly become rancid by exposure to air, and in this regard compares favorably with the best oils.

"Its use produces no specific purgative effect, any more than olive oil.

"With ammonia or solutions of caustic alkalies it rapidly saponifies, forming a white soap."

Analysis by F. Williams, Liverpool, England.

Fatty acids (free)	0·88
Total fatty acids	96·70
Unsaponifiable, mucilaginous, and albuminous bodies	1·34

[SCIENCE.]

THE CENSUS MAPS OF THE UNITED STATES.

As the time is approaching for the eleventh census of the United States, the question whether the maps used for the purposes of the tenth census are satisfactory or not becomes important and interesting. The making of a general map of the United States offers peculiar difficulties on account of the enormous size of the territory they occupy, which is so large that the curvature of the earth's surface has a very appreciable influence upon the map. This will be better understood by the fact that a circle circumscribed about the country cuts off a section of the globe of a little more than 42 deg. aperture, its center being situated north of Omaha. It is impossible to make a single map of the United States which in all its parts is an exact likeness of the country as it exists on the globe. Therefore it is the task of the map maker to find that method of projecting the country upon a flat piece of paper that results in alterations which are as slight as possible, and that agree best with the special object of the map.

We will consider in how far the existing maps satisfy this demand. On the accompanying map the polyconic projection of the coast survey which is in general use is shown in red. The lines of latitude and longitude are obtained in the following way:

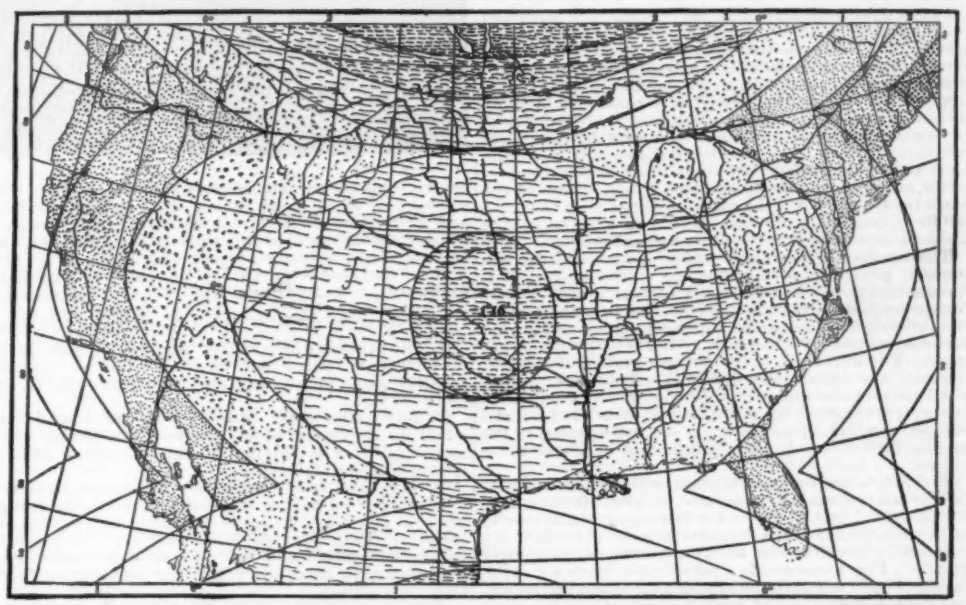
The portion of the globe situated between two parallels that are very close together may be considered as part of a cone, the apex of which lies on the axis of the earth. By developing this cone, the zone assumes the shape of a portion of a circular ring. One zone after another is thus developed. As the side of the cone varies according to the latitude of the zone, the rings do not exactly join each other, but this is remedied by enlarging the lengths of the meridians so as to fill up the gap. It will easily be understood that by this process those parts of the map lying far away from the central meridian will become distorted and too large. We will first study the enlargement of surfaces.

On our map the lines on which the enlargement amounts to 1, 2, 3, 4, 5, and 6 per cent. are indicated by heavy lines. Thus it will be seen that while, in measuring a surface in the central points of the United States, we commit an error no greater than 1 per cent., the latter amounts to more than 6 per cent. in the New England States and in California. If we have a large scale map of the United States showing the distribution of forests, 10·6 square inches in New England will represent the same surface as 10 square inches in Minnesota. Thus we see that we cannot compare the surfaces of various parts of the United States with one another. But, besides this, the form of the single counties is distorted. We have indicated by arrows that direction in which the increase in the lengths of lines is a maximum. In the direction vertical to these arrows the decrease in the lengths of lines is a maximum. The distortion of each part of the map depends upon the relation of these two measures, and may be expressed by an angle. We observe on our map that this distortion exceeds 3 deg. in the outlying parts of the country.

After having thus found the character of alterations in this map, we will proceed to consider whether it meets the demands that must be made upon such a map. The principal objection is that the surfaces are very much enlarged in the outlying districts, which are at the same time among the most thickly settled. It is true that measurements may be made on sectional maps which have various central parallels, but when it is the object of the map to present at a single glance the relative extent of certain phenomena, of whatever character they may be, climatological, geological, or industrial, it is of prime importance that the surfaces in various parts of the map should be equivalent to each other. Maps which have this property are called "authalic" or "equivalent" maps, and we should say that it is the fundamental point that each map used for census purposes should be authalic.

But we might ask, if we agree that this should be the case, will not the alterations of angles become enormous, and thus our ideas of distances become altogether wrong? In order to satisfy this question, we must consider what means we have to preserve the same relation of surfaces all over the map, and at the same time to make the alteration of angles—and, therefore, that of distances also—as small as possible. We may first ask that this alteration be smaller than on the ordinary polyconic projection, and then we will have a map exceeding in value the former. But we present here a map that has not only slighter alterations of angles than the polyconic projection, but the surfaces of which are also preserved all over the map. While in the polyconic projection the alteration of angles very nearly reaches 4°, it does not exceed in our map 1° 16′. While the surfaces on the former projection are enlarged more than 6 per cent. in the outlying regions, they are not at all altered here. Besides this, the construction of the map is more simple than that of the polyconic map, the parallels being all concentric circles and the meridians straight lines, while in the polyconic projection each meridian must be constructed separately. But our projection has still another advantage: it is the best among all the authalic projections that are possible; that is to say, the maximum of distortion cannot be made smaller than it is in our map. A study of the map shows that the distortion reaches its maximum in the extreme southern part of the United States, in latitude 25° north, where it amounts to 1° 16′. Going north, it decreases rapidly, until in latitude 28° 58′ 49″ it vanishes. Then it increases again quickly, and in 37° 58′ 16″ again reaches its maximum of 1° 16′. Farther north it decreases, and on the parallel of 45° 58′ 55″ there is no distortion. While in this zone (from 28° 58′ 49″ to 45° 58′ 55″) the maximum of increase of length is in the direction of the meridians, while the maximum of decrease is along the parallels, it is the reverse north and south of it. From the northern line, on which no distortion exists, it increases, and reaches 1° 16′ on the 49th parallel, the northern boundary of the United States. We have indicated by various shading the regions of equal distortion on both projections. The regions situated east and west of the line of 1° 16′ distortion on the polyconic map are in every respect inferior to our map. But it will be seen that the distortion of angles in the central part of the polyconic map is slighter than in our map. The central parts of our projection, on the other hand, are inferior to the polyconic projection so far as alteration of angles is concerned, while it is superior for census purposes as being equivalent. We must not, however, consider the central parts alone, as the map is intended as one of the United States, not of parts of the States. For the central parts alone, it would be necessary to adopt another equivalent projection. In our map on the lines of maximum distortion the lines whose lengths are increased are 1·1 per cent. too long, while those vertical to them are 1·1 per cent. too short; therefore this is the maximum error that can be made in measuring lengths. In the polyconic projection this error is equal to the amount of deformation of surface, being 6 per cent. in the Eastern and Western States.

The sketch map shows the difference between the distortions of angles in these two maps. In the shaded portions the polyconic projection has a slighter deformation of angles than our projection. In the dotted portions the reverse is the case. This comparison shows that in 48 per cent. of the area of the United States the polyconic projection is superior to ours regarding deformation, the maximum difference in its favor being 1° 16′, while in 52 per cent. of the area ours is superior, the maximum difference in its favor being nearly 4°. A comparison between the amount of deformation in both maps gives the following results:



SKETCH MAP OF THE UNITED STATES SHOWING THE DIFFERENCE BETWEEN THE DISTORTIONS IN THE POLYCONIC AND CONIC PROJECTIONS.

Deformation.	Per cent. of the Area of the United States.	
	Conic Projection.	Polyconic Projection.
0°–1°	51	58
1°–1° 16′	49	12
1° 16′–2°	..	15
2°–3°	..	13
3°–4°	..	2

From these remarks it appears that the conic projection excels the polyconic in every respect.

It appears from our map, very clearly, that the polyconic projection has the valuable property of having very slight distortions on a wide belt situated on both sides of the central meridian. This property makes it valuable for maps showing narrow strips of land only, such as coasts of the ocean and of lakes; therefore it is serviceable for the purposes of the coast survey, particularly as the alteration of surface is of little or no importance to the mariner. The United States, however, have a wide extent in longitude, and a far smaller one in latitude, which makes the projection not well adapted for a map of the whole country. If the object were to construct a map of the whole territory of the United States on this projection, we ought to make use of this fact. Our country is far more extended in longitude than in latitude. But by assuming a system of parallels and meridians, the pole of which is situated near latitude 12° north, longitude 175° west from Greenwich, and using this for a polyconic projection, the greatest distance from the new central meridian will be 13° instead of 30°, and the greatest distortion less than 1° instead of nearly 4°, while the increase

of surface will be less than two per cent. in the outlying portions. This projection may be considered quite a good one, as the central part of the country adjoining about the 40th parallel of latitude would have hardly any distortion. From this line it would increase very slowly northward and southward.

We said, however, above, that, for the purposes of a census, equivalence of surfaces must be the fundamental point of view for the construction of a map, and as even the oblique projection just mentioned is not equivalent, it cannot be accepted. For the same reason it is necessary to take into account the spheroidal shape of the earth, which makes the computation of oblique projections difficult; therefore, they will be only chosen if they offer great improvements upon others.

Assuming the central point of a circle circumscribed about the United States as a zenith, and computing a conical projection that is equivalent, and in which the alteration of angles is as slight as possible, we shall find that the maximum alteration of angle is not more than 58′, the map including the whole territory of the United States. We should recommend this map, if it were not for the fact that there would be an open sector of 10° aperture running from the center near Omaha to the northern boundary. This is produced by the development of the cone upon which the map has been projected. The existence of this open sector is so serious an objection that the decrease of 18′ in the deformation cannot be considered an equivalent.

By assuming an oblique conic projection the alteration of angle might be reduced to 1° 9′, but the difficulty of computing this projection for the spheroid induces us to discard it. A thorough investigation into the properties of all known projections leads us to the conclusion that the projection we propose here is the best that is possible for census purposes, and the only one that ought to be used for it. The easiness of computation of the elements adds to the properties that qualify it for an extensive use.

DR. F. BOAS.

[NATURE.]

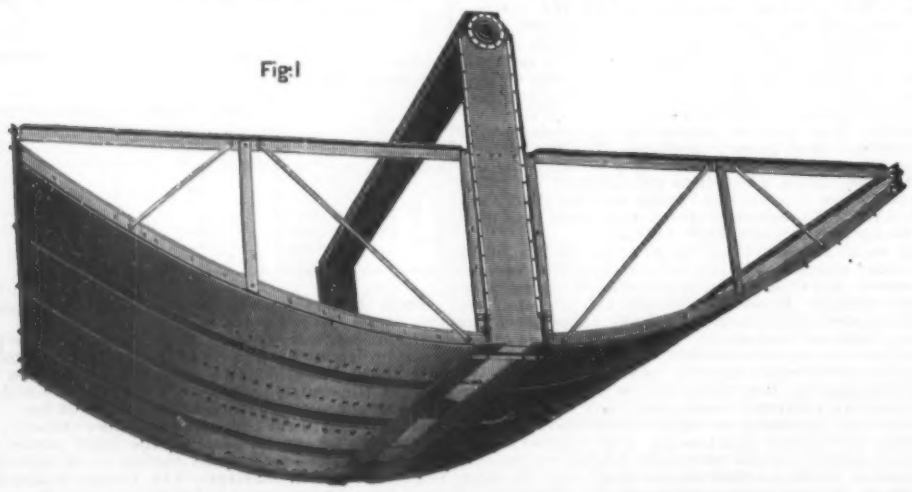
THE SUN MOTOR.

INDIA, South America, and other countries interested in the employment of sun power for mechanical purposes, have watched with great attention the result of recent experiments in France, conducted by M. Tellier, whose plan of actuating motive engines by the *direct* application of solar heat has been supposed to be more advantageous than the plan adopted by the writer of increasing the intensity of the solar rays by a series of reflecting mirrors. The published statements that "the heat-absorbing surface" of the French apparatus presents an area of 215 square feet to the action of the sun's rays, and that "the work done has been only 43,360 foot-pounds per hour," furnish data proving that Tellier's invention possesses no practical value.

The results of protracted experiments with my sun motors, provided with reflecting mirrors as stated, have established the fact that a surface of 100 square feet presented at right angles to the sun, at noon, in the latitude of New York, during summer, develops a mechanical energy reaching 1,850,000 foot pounds per hour. The advocates of the French system of dispensing with the "cumbrous mirrors" will do well to compare the said amount with the insignificant mechanical energy represented by 43,360 foot pounds per hour developed by 215 square feet of surface exposed to the sun by Tellier, during his experiments in Paris referred to.

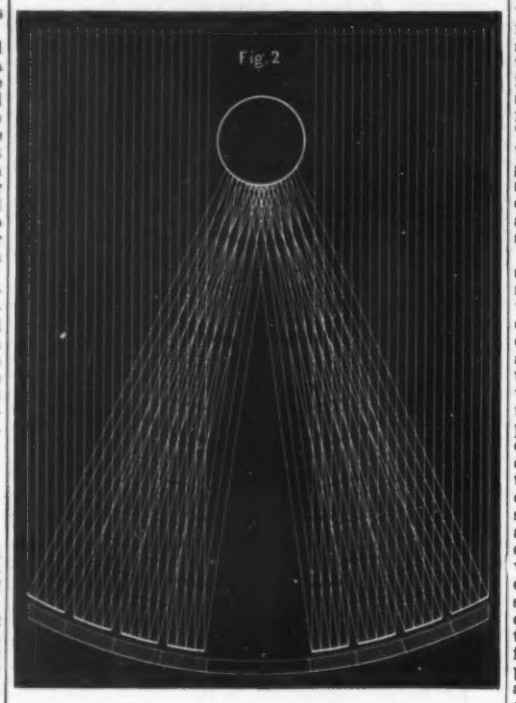
The following brief description will give a clear idea of the nature and arrangement of the reflecting mirrors adopted by the writer for increasing the intensity of the solar heat, which imparts expansive force to the medium propelling the working piston of the motive engine. Fig. 1 represents a perspective view of a cylindrical heater, and a frame supporting a series of reflecting mirrors composed of narrow strips of window glass coated with silver on the under side. The frame consists of a light structure of wrought iron or steel, provided with transverse ribs, as shown by the illustration, each rib being accurately bent to a parabolic curvature whose focus coincides with the axis of the cylindrical heater. It need hardly be stated that the mirrors supported by the said transverse ribs continue from side to side of the frame, which accordingly resembles a parabolic trough whose bottom is composed of mirrors. It will be readily understood that this trough with its bent ribs and flat mirrors forms a perfect parabolic reflector, to which a cylindrical heater, as stated, may be attached for generating steam or expanding the gases intended to actuate the piston of the motive engine. Regarding the mechanism for turning the reflector toward the sun, engineers are aware that various combinations based on the principle of the "universal joint" may be employed.

Fig. 1



Concerning previous attempts made in France to utilize solar energy for mechanical purposes, it is well known that practical engineers, having critically examined Mouchot's solar engine, which M. Tellier proposes to supersede, find that it is incapable of developing sufficient power for any domestic purpose. Again, the investigations carried out by order of the French government to ascertain the merits of Mouchot's invention show that, irrespective of the great expense of silver-lined curved metallic reflectors for increasing the insufficient energy of direct solar radiation, these reflectors cannot be made on a sufficient scale for motors having adequate power to meet the demands of commerce; nor is it possible to overcome the difficulty of rapid wear of the delicate silver lining of the metallic reflectors consequent on atmospheric influence, which after a few hours of exposure renders their surface tarnished and ineffective unless continually polished. A glance at the accompanying illustration (Fig. 1) shows that the reflector constructed for my sun motor differs altogether from that originated by Mouchot, which Tellier's apparatus, tested at Paris, was intended to displace.

Fig. 2



DESCRIPTION OF THE ILLUSTRATED REFLECTOR.

(1) The mirrors which reflect the solar rays are devoid of curvature, being flat narrow strips of ordinary window glass, cut to uniform width and length, perfectly straight.

(2) The under sides of said strips are coated with silver by a process which prevents the action of the sun's rays from destroying the silver coating as in ordinary looking glasses.

(3) The mirrors supported by the bent metallic ribs, extending from side to side of the parabolic trough, are held down by the heads of small screws tapped into the ribs. Thin slats of wood may be introduced between the mirrors and the ribs—an expedient of some importance in localities where the reflector is exposed to high winds.

(4) It needs no explanation that the *reflecting surface* of the mirrors cannot become tarnished by atmospheric influence, since the bright side of the silver coating is permanently protected by the glass; hence it will be only necessary to remove *dust* from the mirrors—an operation readily performed by feather brushes secured to light handles of suitable length.

(5) The frame of the reflector, being composed of rolled bars of iron or steel, requires no finish, excepting the top of the transverse ribs, which must correspond accurately with a given parabolic curvature. It should be observed that the needed accuracy is readily attained by a cutting tool guided by a bar of proper form.

(6) Regarding cost of construction, it will suffice to state that manufacturers of glass, both in the United States and Germany, supply the mirrors, cut to exact size and silvered, at a rate of 60 cents per square foot, the weight 106 pounds per 100 square feet. Consequently the cost of the reflector and heater for the sun motor will not much exceed that of a steam boiler and appurtenances, including chimney. The cost of the engine apart from the reflector will not be greater than that of an ordinary steam engine.

(7) With reference to durability, it will be evident that the light metallic frame with its mirrors, and a heater acted upon only by reflected solar heat, will last much longer than steam boilers subjected to the action of fire, soot, and corrosion.

Let us now briefly consider the distinguishing feature of the sun motor—namely, the increase of the intensity of the sun's radiant energy by *parallel* rays and *flat* reflecting surfaces permanently protected against atmospheric influence. It has been supposed that the lens and the curved reflecting surface, by converging the sun's rays, could alone increase the intensity of radiant heat. But Newton's demonstration, showing that the temperature produced by solar radiation is "as the density of the rays," taught me to adopt in place of curved surfaces and converging rays, flat surfaces and parallel rays, as shown by Fig. 2, which represents a transverse section of part of the reflector. The direct vertical solar rays, it will be seen, act on the mirrors; while the reflected rays, divided into diagonal clusters of parallel rays, act on the heater, the surface of which will thus be exposed to a dense mass of reflected rays, and consequently raised to a temperature exceeding 600° F. at noon during ordinary sunshine.

The cost, durability, and mechanical energy of the sun motor being thus disposed of, it remains to be shown whether the developed energy is continuous, or whether the power of the engine changes with the increase and diminution of zenith distance and consequent variation of atmospheric absorption. Evidently an accurate knowledge of the diathermancy of the terrestrial atmosphere is indispensable to determine whether the variation of the radiant energy is so great that the development of constant power becomes impracticable. Of course, manufacture and commerce demand a motor developing *full power* during a modern working day of *eight* hours. Observations relating to atmospheric diathermancy continued during a series of years enable me to assert that the augmentation of solar intensity during the middle of the day is so moderate that, by adopting the simple expedient of wasting a certain amount of the superabundant heat generated while the sun is near the meridian (as the steam engineer relieves the excess of pressure by opening the safety valve), a uniform working power will be developed during the stipulated eight hours. The opening of the safety valve, however, means waste of coal, raised from a great depth at great cost, and possibly transported a long distance, while the radiant heat wasted automatically by the sun motor is produced by fuel obtained from an inexhaustible storehouse, free of cost and transportation.

It will be proper to mention that the successful trial of the sun motor described and illustrated in *Nature*, vol. xxxi., p. 217,* attracted the special attention of land owners on the Pacific coast then in search of power for actuating the machinery needed for irrigating their sunburnt lands. But the mechanical detail connected with the concentration at a single point of the power developed by a series of reflectors was not perfected at the time; nor was the investigation relating to atmospheric diathermancy sufficiently advanced to determine with precision the retardation of the radiant heat caused by increased zenith distance. Consequently no contracts for building sun motors could then be entered into, a circumstance which greatly discouraged the enterprising Californian agriculturists prepared to carry out forthwith an extensive system of irrigation. In the meantime a simple method of concentrating the power of many reflectors at a given point has been perfected, while the retardation of solar energy caused by increased zenith distance has been accurately determined, and found to be so inconsiderable that it does not interfere with the development of constant solar power during the eight hours called for.

The new motor being thus perfected, and first class manufacturing establishments ready to manufacture such machines, owners of the sunburnt lands on the Pacific coast may now with propriety reconsider their grand scheme of irrigation by means of sun power.

JOHN ERICSSON.

THE TANCARVILLE CANAL.

THE first series of works now in course of execution or already finished at the new port of Harve includes the construction of graving docks Nos. 5 and 6, established, like dock No. 4, and near it, upon the platform of the Eure basin, and the canal from Havre to Tancarville.

The new graving docks present one interesting peculiarity, which consists in the establishment of a ditch which permits of dismounting and remounting the rudders of large vessels *in situ*.

The canal from Havre to Tancarville, of which the direction line is shown in Fig. 2, is designed to facilitate communications by river boats between the port of Havre and the Seine, and to prevent those dangers to boats of interior navigation that accompany the crossing of the estuary of the river. We borrow a description of it from a notice published by Mr. Maurice Widmer, government engineer at Havre.

The canal opens in the Eure basin at about 150 yards to the south of graving dock No. 4, afterward bends toward the northeast by a curve of 1,900 feet radius, traverses the plain of Graville, passes before Harfleur in following a curve of 9,800 feet radius, runs along the hills that border the valley, and reaches Tancarville by a straight line. It finally debouches in the Seine at the foot of Cape Tancarville, at 6 miles below Rouen, with a total length of 15 miles.

The canal is completed by a branch which connects it with the port of Harfleur and which replaces the Lezarde route that was formerly taken by boats frequenting this port, and that is now intersected by the new route. It has, besides, a turnout and a fluviatile basin at Havre, and two other turnouts, one at Graville and the other at the end of the Tancarville sluices, as well as a 300 foot dock at Harfleur. Formed of a single reach, it terminates at its two extremities in lock chambers, which are necessitated by the position of the plane of water that has been selected intermediate between the planes of high and low tide at Havre and Tancarville. Its depth between Tancarville and

* Also described and illustrated in the SCIENTIFIC AMERICAN SUPPLEMENT No. 422, February 2, 1884.

the Harfleur branch has been fixed at 11½ feet, say one foot more than the minimum depth that the Seine will have above Rouen when the work of improving the river is finished. Between Havre and the Harfleur branch, and in the latter, the depth is 19 feet.

Communication between the two banks at Havre will be made by revolving bridges. Beyond, a certain number of ferries have been provided for. There has been no need of protecting the taluses by walls; under water they are perfectly stable. In order to prevent their crumbling above water, they have been consolidated by sodding and by the planting of reeds upon steps at their base.

The lock gates at Havre have two leaves, and are constructed on the same principle as those of the Transatlantic and Bellot locks. Those of the Tancarville lock chambers, on the contrary, have but a single leaf. Each of them is so constructed as to float, whatever be the level to which the surrounding water rises above its minimum, which is nine feet. To this effect, there

FIG. 1.—PRESENT STATE OF THE PORT OF HAVRE.

has been placed, at this level a horizontal girder, which makes a tight bridge and forms, with the lower part of the gate, a box in which is placed the ballast designed to secure an equilibrium, and into which the water can never penetrate. Upon this girder are fixed three vertical latticed girders, against which rest two horizontal pieces that support the uprights to which the iron plates of the edges are riveted. The gate is completed at one of its extremities by a rectangular box that is provided with a pivot above and a step bearing beneath. The pivot engages in a collar fixed in the masonry, and the bearing rests upon a pivot sealed into the floor. Cast iron aqueducts, capable of being closed by gates, permit the upstream water to enter the gate freely, over the watertight bridge, so that, when the water rises above nine feet, the equilibrium is affected only by the immersion of the irons. The lower box or compartment communicates with the upper part through iron plate conduits starting from the tight bridge.

This system of gates, devised by Mr. Bellot, has great advantages over miter gates, when the apparatus are submitted to the action of billows. Their maneuvering is simplified, and the closing of a single leaf requires less attention.

The total amount of material excavated from the canal and the Harfleur branch is about one hundred and seventy-five million cubic feet. But a very small quantity of this work was done by manual labor, and that only in such parts as had been rendered dry by pumping, as at the Graville turnout and the Harfleur branch. A much larger bulk of earth was extracted by means of a Couvreux excavator,

Between Lezarde and Tancarville, the contractor removed all the material by means of the excavator and dredges and deposited it upon the south bank by means of transporters. After the water was let into the cutting, the canal was finished by means of three bucket dredges of similar type. To the first of these was lashed a lighter carrying a centrifugal pump and an engine. The suction pipe of the pump ended in a box submerged in the water to half of its height, and into which the products of the dredging fell. The pump sucked up a mixture of water and debris, which it

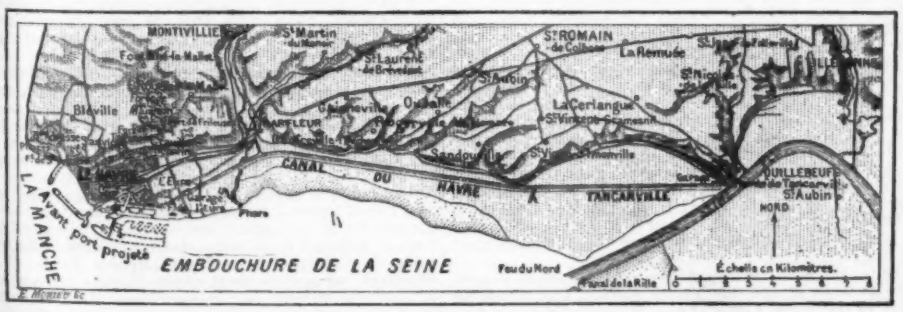


FIG. 2.—LINE OF THE TANCARVILLE CANAL.

threw upon the bank through the intermedium of pipes, supported in part by rafts and in part by small trucks running upon rails. In the other systems, the pump sucked up water only, and forced it into apparatus where it met the materials extracted by the dredge, diluted them, and sent them to the bank through pipes.

The Tancarville canal is the indispensable complement of the works of improvement of the Seine between Paris and Rouen, and, in opening toward Havre a navigable route accessible to river boats, it will, to the exclusion of Anvers, assure to the French port the patronage of the industries of Paris and of the central and eastern departments. In a word, it tends to give our great Channel port the same advantages as the immense network of navigable routes that surround it. The total cost of the canal was $4,640,000.—*La Nature.*

THE BOFORS CAST STEEL GUNS.*

By Captain O. E. MICHAELIS, Ph.D., United States Army.

I AM indebted to Professor Richard Akerman, of the Stockholm School of Mines, a high authority on steel, for the data, a translation of which is herewith offered to those interested. The professor informs me that a 6 inch gun has been cast since the tests described were undertaken. The Swedish authorities consider the Bofors guns as reliable as those heretofore purchased from Armstrong and Krupp. Certainly a careful consideration of the sterling physical qualities developed by the Bofors steel, and their subsequent confirmation in actual exhaustive trial, must greatly encourage all who believe in the thorough investigation of the feasibility of our casting steel guns. It will be urged that the pieces submitted to such crucial tests were of small caliber. True; but Rodman began with an 8 inch, continued with a 10 and a 15 inch, astonished the world with the huge 20 inch, and had actually designed a 30 inch thunderer at the close of our war. The first pneumatic dynamite gun was a 2 inch tube, but under the superintendence of Captain Zalinski it has gradually grown to 15 inches, and has aroused the world's interest. Progress is a synonym of development; the experience gained with small calibers will lead to their increase. Such must be the result, unless it can be shown that there is an intrinsic narrow limit which cannot be passed. I am not of those who believe in the existence of a steel cast "so far, but no farther." The symmetry of the Swedish metric data disappears in the translation.

The metal used at the Bofors works in gun manufacture is unforged open hearth steel, cast without blow holes. It has from time to time been asserted that it is impossible to produce open hearth steel with sufficient constancy to warrant its use as a gun metal, possessing all required guarantees resulting from homogeneity. Although the Martin-Siemens process is the only one that affords the utmost facility for testing with precision at every period of fusion the condition of the steel, yet, generally speaking, the criticism is founded in truth. The fact is that, especially in the fabrication of open hearth steel, ingredients are used the quality of which leaves much to be desired. And, as a rule, this must be the case; for the Martin process presents this advantage, from the standpoint of economy, that with the exception of manganiferous pig, forming about 30 per cent. of the bath, the rest may be made up of unselected scrap of every description. And, further, the pig itself is not too frequently of satisfactory brand. Even when the best ores are used for the production of the pig, charcoal is rarely used in the blast furnaces outside of Sweden. For this fuel, comparatively costly, coke is usually substituted, less expensive, but which, as an offset, produces a much less pure pig. This does not obtain at Bofors. Not only are ordinary pig and spiegeleisen made from the very best Swedish ores, but also the only fuel employed is charcoal. In addition, the iron used for decarburization is made at Bofors, specially for the purpose, of Lancashire ores, generally acknowledged as the best in the market. We must add that wood alone is used in the generators. Under these conditions the same excellent product is always secured. As already stated, at every moment and with absolute accuracy, the carbon point of the bath may be determined, by the examination of small specimens taken from the furnace. It is clear that a more homogeneous metal can hardly be obtained by any other process.

We cannot deny the good effect of forging upon honeycombed steel blocks, for it is the only means of rendering such steel fit for technical purposes; but, on the other hand, it must be admitted that it is both legitimate and useful to endeavor to make steel which shall be entirely free from blow holes, without the necessity of subjecting it to hammering. Indeed, the forging of great blocks of steel is too delicate an operation to be always successful; and, moreover, it is extremely costly. Before the block is put under the steam hammer, it must be brought to the proper temperature—there is risk of over or under heating. The hammering, too, must stop at the right moment, for the block may be fissured if it be hammered after becoming too cool.

Owing to these circumstances, and also to others, it occasionally occurs that the blocks are so injured under the hammer as to necessitate their relegation to the scrap heap. Sometimes these injuries are not made manifest until the machining of the block is well advanced; sometimes they remain altogether undiscovered. As a matter of fact—at least, when it is a question of heavy guns of forged steel—it is necessary to make use of blocks that have numerous and perfectly apparent defects; for if this were not done, the rejections would be too many, and would greatly enhance the cost of the undertaking. To avoid the difficulties and the risks inherent in the hammering of huge blocks of steel, the Bofors works, as at Terrenoire, avails itself of the method of casting steel without blow holes. As it is well known, this method consist in the introduction of ferro-silicon and ferro-manganese in proper quantity just before drawing the bath. Unquestionably the steel obtained by this process is free from blow holes, if the fusion has been well managed; but fracture is crystalline and very bright, and, though this comparatively crude product shows great elasticity and tenacity, it is yet far from possessing completely these two qualities, and especially ductility, to a sufficiently high degree, although it acquires them at once by the succeeding treatment.

This treatment is as follows. The cast block is thoroughly reheated and then buried in pulverized cinders, where it remains until completely cooled. As a rule, after this operation, the block possesses very great elasticity and tenacity, and at the same time very considerable ductility. After being rough finished and bored to a diameter slightly less than the regulation caliber, the block is again reheated, and oil tempered. It is then annealed at a very low temperature to counteract the tensions engendered by the oil tempering. The block is now ready for finishing. If the carbon point lies between 0·3 and 0·4, the bars, cut from the block, show all the physical qualities which characterize the best crucible steel of mean hardness. The fracture is also fine in grain and of silken sheen, appropriate for this steel. The tension tests of the steel used in making various experimental Swedish army and navy guns show the density of the steel to be from 7·82 to 7·84.

In the firing test, the first experimental piece was a 4 pounder smooth bore ordered by the navy. This caliber was selected owing to the fact that in Sweden 4 pounder test tubes are always cast at the same time as are the lining cylinders of heavy cast iron steel banded guns. This small piece is submitted later to endurance tests, if the inspecting officer deem it necessary, according to a programme established once for all. Consequently a very complete knowledge is thus gained of the strength of the guns; and it was deemed desirable to obtain comparative results for the old and new metal. The following are construction data of the 4 pounder smooth bore: Caliber, 3·295 inches; total length, 59·056 inches; length of bore, 57·441 inches; maximum exterior diameter, over powder chamber, 11·164 inches; diameter of powder chamber, 3·295 inches; weight of gun, 2,445 lb. Before finishing, the gun was annealed in pulverized cinders, but was not oil tempered. The physical test to which a specimen taken from the sprue head, the worst end of the block, was submitted gave the following results: Elastic limit, 31,700 lb. per square inch; tenacity, 87,300 lb. per square inch; coefficient of elasticity, 33,000,000; elongation in 3·937 inches (100 millimeters), 13 per cent.; contraction of original section, 14·4 per cent. The carbon point was 0·37.

In the endurance tests, 322 rounds were fired. Up to the 144th round, straw had been used between the last projectile and the charge, and thin wooden disks between the projectiles, which were solid and of cylindrical form. As no extraordinary enlargement had occurred during the first 300 rounds, musket powder was substituted at this stage for the small-grained cannon powder heretofore used. However, the pressure was not increased—easily explained by the fact that considerable erosion had occurred at the seat of the projectile, an unavoidable effect, due to the necessity of using windage projectiles in this smooth-bore gun. From the 312th round cannon powder was used, and at the same time the method of testing was entirely changed. After having inserted the charge, the bore was filled with solid plugs and the gun laid horizontally, so that the forward plug, projecting from the muzzle, rested against a cast iron block weighing over 2,500 lb. and firmly fixed in position. The gun thus laid was then fired. Usually the gun, in recoiling, was received in a sand rampart made for the purpose. Sometimes, however, it flew up, presenting the strange sight of a cannon gyrating among the tree tops. At the 11th round, with the cannon itself acting as a projectile, that is to say, after 322 rounds of proof firing, the gun burst into several pieces.

The strongest cast iron guns of the same construction tried to destruction had endured only two hundred and nineteen proof rounds. The exceedingly favorable result of the first trial of the new gun metal induced the Swedish ordnance authorities to experiment with a 4·6 inch steel cast siege gun. The following are the construction data of the 4·6 inch gun No. 1: Caliber, 4·6 inches; total length (29·9 calibers), 137·8 inches; length of bore (28·5 calibers), 131·4 inches; exterior diameter, maximum, over powder chamber, 12·6 inches; exterior diameter of body, over powder chamber, 7·83 inches; diameter of chamber, 4·88 inches; number of grooves, 36; depth of grooves, 0·049 inch; width of lands, 0·118 inch; final twist, in calibers for one turn, 30; cross section of bore, 17·13 square inches; volume of bore, 2.382 cubic inch; capacity of chamber (shell in place), 267 cubic inches; weight of gun, 2,628 lb. Otherwise the construction of the piece is very much like the Krupp mantle guns, except that it has the screw, instead of the wedge, fermature. The two main parts of the gun, to wit, the mantle and the body, as well as the breech screw, were annealed in pulverized cinders before machining, but were not tempered. The tension tests, of bars taken from the best ends of the two parts, gave the following results:

* Abstract of paper read before the American Institute of Mining Engineers.

	Mantle.	Body.
Carbon point	30	25
Elastic limit	33,500	42,600
Tenacity	77,600	81,800
Coefficient of elasticity	32,300,000	32,300,000
Elongation in 3·937 inches (100 millimeters)	23·5 per ct.	21·5 per ct.
Reduction of area at rupture	30·8 per ct.	21·9 per ct.

In the endurance tests, 1,041 rounds were fired. During these tests Swedish large grain cannon powder was always used. Although the grains of this powder are relatively small, it is, however, a little less violent than that of 0·25 inch to 0·4 inch granulation (Hamm or Rottweil), as it was not milled under stone. Still, the two-tenths powder is yet somewhat too quick for a 4·6 inch gun. The maximum powder pressures show, consequently, much variation, dependent upon the year of manufacture. Notwithstanding this drawback, the gun has stood well these severe tests. In accordance with the programme, the gun was first fired one thousand regulation rounds. This firing produced no erosions whatever; the diameter of the chamber was enlarged about 0·01 inch, due to the great malleability of the metal. It was noted that after the 800th round there was no augmentation of the enlargement. The extremity tests began with round No. 1,001, but were interrupted for a special trial. It should be noted that after the rounds with heavy charges, during which the pressures rose to 34,400–47,800 lb., no increase of enlargement was observed. There was no erosion of the bore, and no scoring was evident in front of the cone joining chamber and bore. When the extremity test was resumed, the gun burst at the first round (charge 8·82 lb., projectile 73·6 lb.). In this round the gas pressure unexpectedly rose to 80,800 lb.

The cause of this abnormal pressure was clear when the projectile next to the charge was recovered. In order to use the projectiles over again, they had been made of Swedish gun iron of great tensile strength, but as a result exceedingly soft. The projectile was consequently upset under the pressure of the gas, and was slugged through the bore as a lead ball would be. Indeed, the lands cut into the base of the projectile to the depth of 0·04 inch. The gun burst in this way. The part of the mantle behind the front thread of the breech screw seat was torn off and broken into two large pieces, which, together with the breech screw and gas check ring, were projected to the rear. The body of the gun, on the other hand, remained completely intact. There were no signs of cracks, although the chamber had been enlarged in one round to the very large amount of 0·06 inch. It must further be added, in connection with the great strength of the gun body, that the maximum exterior diameter over the chamber of this piece, at once long and light, was only 12·6 inches, a comparatively small dimension (the corresponding diameter of the light Krupp gun is 13·4 inches).

The trial having been thus, in general, very successful, the Swedish ordnance authorities determined to continue them upon a larger scale, and ordered for this purpose four guns, three 3·3 inch field guns and one 4·6 inch siege piece. As the steel of the first 4·6 inch gun had shown itself a trifle soft, it was determined that the carbon point should be slightly raised, and that the blocks should be oil tempered.

In construction, the 3·3 inch guns are exactly like the field guns furnished to the Swedish artillery by Krupp—mantle guns with cylindro-prismatic wedge. The 4·6 inch gun No. 2 was constructed very much like No. 1. But as the seating of the Broadwell ring decidedly weakened the end of the gun body, made apparent by the enlargement of the back end of the chamber, an enlargement which diminished toward the front, the new piece was re-enforced, after the Krupp method, by a band placed centrally over the ring seat. Before machining, the mantle and body blocks were annealed in pulverized cinders. To make the metal harder, and to enable it to better resist permanent deformation, the various parts, as has already been mentioned, were oil

Construction Data of the 3·3 inch Guns and the 4·6 inch Gun No. 2.

		3·3 inch Field Gun.	4·6 inch Siege Gun.
Caliber	Inches	3·3	4·6
Total length	"	90·5	137·8
Total length	Calibers	27·4	29·9
Maximum exterior diameter over chamber	Inches	9·06	12·76
Diameter of gun body over chamber	Inches	5·91	7·83
Diameter of chamber	"	3·94	4·8
Number of grooves		24	36
Depth of rifling	Inches	0·039	0·049
Width of lands	"	0·138	0·118
Final twist in calibers for one turn		33	30
Cross section of bore	Square inches	8·59	17·13
Volume of bore	Cubic inches	751	2252
Capacity of chamber (shell in place)	"	109	207
Weight of gun	lb.	1010	2731

tempered after rough finishing and first boring. Bars for tension tests were cut from the best ends of the various parts. The elastic limit and the tenacity for gun body No. 3 far exceeded the required limit, while on the other hand its ductility was lower than usual, and it was thought best to soften it by a special operation. This undoubtedly beneficial procedure was, however, to avoid loss of time, not undertaken. Bars taken from the worst ends of the castings were, as a rule, weaker than those taken from the best ends. The least favorable result from the worst bars was about the same as for gun No. 3. It had an elastic limit of 38,400 lb., a tenacity of 86,300, and a stretch in 3,937 inches of 3·4 per cent. The end here called the worst is sometimes as good as, even though rarely better than, the other. It must further be stated that the variation between the two ends of the parts has little effect upon the strength of the guns, because it is very small, and because the best end is always toward the breech.

According to the programme of firing, each of the three 3·3 inch guns were to be fired 2,000 rounds with standard charge and projectile, and thereafter two of them were to be subjected to extreme proof. The 4·6 inch gun was to be fired 1,000 regulation rounds, and then to be subjected to extreme proof. This programme was carried out without change, except that the extreme proof of the 4·6 inch has not yet taken place. After the 2,000 rounds with standard charge and projectile there were no signs of scoring in any of the 3·3 inch guns, and no discoverable enlargement of chamber. After the 2,060th round with gun No. 1, and the 2,080th round with gun No. 2, the enlargement could no longer be observed. Generally speaking, the enlargement, after the same number of rounds, is greater in the gun of softer and weaker steel (No. 1) than in the other. It is worth special notice that the horizontal enlargement greatly exceeds the vertical. The reason of this is that the breech slot, which is very large, and traverses the mantle from side to side, weakens the gun considerably in a horizontal direction. Gun No. 1 burst at the 2,152d round into several pieces. On the other hand, gun No. 2 was disabled by a crack, which began at the right front of the slot and disappeared a little in front of the trunnion. The crack at its origin (near the slot) was about 0·016 inch wide, and penetrated the entire wall of the mantle. The gun body, however, was uninjured. It had withstood the enormous enlargement of 0·171 inch (horizontal) and 0·138 inch (vertical) without any sign of cracking. So far as our knowledge extends, this has never happened before in the extreme proof of a steel gun. Such results are met with only in bronze guns, or possibly in wrought iron guns. As evidence of the excellent qualities of Bofors steel as a gun metal, this 3·3 inch piece has been placed in the Ordnance Museum at Stockholm. As already stated, the 3·3 inch gun No. 3 showed no injuries; it may be used without danger for extended firing trials. As to the 4·6 inch gun No. 2, there is little to be said. It shows considerable enlargement of the chamber—much larger than that observed in the 4·6 inch gun, No. 1, of softer steel and weaker construction. This is explained by the fact that gun No. 2 was fired most rounds with the very quickest powder delivered during the years 1880, 1881, and 1882, while for gun No. 1 the slowest powder of 1887 was used. No enlargements were observed in the rear of the chamber, thanks to the favorable action of the re-enforce band.

Besides these tests, the Swedish navy has tried a 4·7 inch ship gun, selected at haphazard from a delivery. This was a banded piece, the tube alone being of Bofors steel. The hoops were puddled steel; the gun weighs 4,167 lb., the charge 16 lb., the standard projectile 48·4 lb. Up to the present time the piece has been fired eighty-six rounds, about one-half with 17 lb. charges, giving an initial velocity of 1,723 feet, and an energy—total, 998 foot tons, and per pound of gun's weight, 1,179 foot pounds, with a pressure of 41,100 lb. During the practice no scoring has occurred, and no enlargement of the chamber is perceptible. From what has been stated, it is seen that the Swedish authorities have submitted the seven Bofors steel guns to exhaustive experiment, which has demonstrated that this gun metal is perfectly reliable. This extremely favorable conclusion is due to the pains taken both by the army and the navy in carrying out the tests. The Swedish ordnance department, especially, has done everything in its power to facilitate these trials, so important to the country. The Bofors plant is now in condition to execute large orders for guns, howitzers, and mortars (at present, maximum length 17½ feet, maximum weight 35,000 lb.), as well as for gun carriages, limbers, implements, ammunition wagons, and appropriate supplies. In sending orders, they should be accompanied either by the necessary drawings, or by proper specifications, in which latter case the works will make the drawings subject to approval. Thanks to its economical method of manufacture, the establishment will do work at very moderate cost.

STEEL AT THE GLASGOW INTERNATIONAL EXHIBITION.

THE steel exhibits in the Glasgow Exhibition have an exceptional interest in view of the remarkable development of the Scotch mild steel industry since the year 1873, when the Steel Company of Scotland commenced operations with four small Siemens furnaces at Hallside, about five miles east of Glasgow. The late Dr. Siemens has stated that the formation of this now vast concern was the result of experiments made by the Tharsis Company in 1867, with a view to the utilization of the residue from its treatment of pyrites. The experiments were carried out at the works of Messrs. Rowan & Co., Glasgow, in a specially built Siemens furnace, and encouraged the belief that steel suitable for rolling into rails could be manufactured from the residue, "blue billy," of which the Tharsis Company possessed immense accumulations. These hopes were never commercially realized, and from the first steel was made at Hallside from hematite pig, scrap and ore. The finished product was, for several years, principally rails; but in 1876 the directors, encouraged by the success of the Landore Company, put down a 26 in. plate mill, and commenced the manufacture of steel plates for shipbuilding and engineering purposes. About a year later Mr. Riley became general manager, and thereafter the company's business extended rapidly. Other firms, commencing with Messrs. Beardmore & Co., in 1879, embarked in the new industry, and in a few years the Clyde basin became the greatest mild steel producing center in the world.

In the exhibition the larger steel exhibits are all placed in the avenue of the machinery section, the imposing trophy of the Steel Company of Scotland calling first for attention. This stand is an elaborate structure, with four corner columns, each composed of a group of bars or rails, supporting a cornice of heavy steel beams, the whole being roofed in by a large boiler plate with four flanged furnace holes. The sides of the pavilion thus formed are filled in with a variety of interesting articles illustrating the manufactures of the company. At one side is shown a collapsed flue from the boiler of the SS. County of Durham; several of Riley's patent sleepers; a ⅛ in. plate, dished by the explosion on its surface of 8 oz. of dynamite; and a cast steel engine frame of intricate pattern, similar to one supplied to H. M. S. Pheasant. At the south end is a large flanged boiler front plate ¾ in. thick, and a fine collection of cast steel gear wheels; the opposite side is filled by a cast steel double legged engine column weighing six tons, similar to those supplied to the new Inman twin screw vessel City of New York. Passing under the legs of this casting, the visitor finds himself in the interior of the stand, where is shown a large number of marine castings as supplied to various war vessels, cast and forged steel projectiles and ordnance requirements; a solid two-throw crank shaft, about 9 in. diameter; and a closely coiled plate 18 in. wide, ⅝ in thick, and no less than 130 ft. in length. This plate is worth inspection, and was rolled in a universal mill recently erected at the company's Blochairn Works. Welded steel pipes with Riley's patent joints; rolled blanks for eye bars; and a very large assortment of rail and bar sections and other articles made by the firm are displayed round the upper part of the exterior of the stand; while every available nook about the sides and base contains some test in the shape of bent and twisted samples of steel, which fully demonstrate the excellent quality of the material produced by the company.

The Steel Company of Scotland has now at its Hallside Works eighteen large Siemens melting furnaces, capable of an annual production of 110,000 tons of ingots. The mechanical plant consists of three 10 ton steam hammers, with a smaller one for light forgings; a 28 in. cogging mill; a 26 in. rail and bar mill; one 18 in. and one 14 in. bar mill, and two 26 in. plate mills. The steel casting foundry is fitted with all appliances necessary for the production of castings up to 30 tons in weight, and in this branch of its business the firm has a deservedly high reputation. A large machine shop with tools of great power has recently been completed, and the Steel Company is now prepared to supply turned and finished forgings and castings for all purposes. In 1880 the Blochairn Iron Works, situated on the northeast border of Glasgow, were purchased by the company, and converted for the manufacture of steel.

There are now at Blochairn thirteen melting furnaces, including several Batho furnaces, with a producing power of 90,000 tons of ingots yearly; three large steam hammers; one powerful slab cogging mill, with hydraulic shears capable of cutting 30 in. by 10 in. blooms; three large plate mills; one universal mill for rolling bars or plates up to 30 in. wide with finished edges, also bars or blanks with thickened ends for suspension links; two sheet mills, one bar mill, and a guide mill. There is also at these works a complete plant for flanging boiler plates by hydraulic machinery, and for machining the edges of the plates.

The combined annual output of the Hallside and Blochairn Works amounts to between 120,000 and 150,000 tons of finished steel, a quantity considerably in excess of that produced by any other open hearth steel making firm in any country.

Messrs. David Colville & Sons, Dalzell Steel and Iron Works, Motherwell, come next in order. Their exhibit is arranged in the form of a truncated pyramid of polished wood, covered with a multitude of samples, showing apparently every possible method of testing steel plates and bars. On the top of all is a boiler shell plate, measuring 30 ft. by 7 ft., folded into a circular form, with a boiler end plate, 10 ft. in diameter, at each side. Plates and bars, the chief products of this firm, do not lend themselves readily to the formation of an artistic or striking display; but the extensive collection of tensile, compressive, torsion, dishing, folding, and drifting tests, all treated cold, are highly interesting, and afford ample proof of the excellent quality of the Dalzell brand of Siemens steel.

We may point out as particularly worthy of examination several small steel disks, which originally measured 3½ in. diameter, with a ¾ in. hole in the center. This hole has been drifted out cold until it exceeds the external diameter of the plate previous to the operation. Several dished bowls are shown, which were shaped instantaneously from a flat disk by a single blow of a steam hammer. Cold flanging has long been regarded as a desideratum, and a boiler end plate exhibited with a flue hole flanged cold by one of Lyall's patent machines will interest boiler makers; while the collection of hot worked samples, some of which were done by Messrs. Galloway, of Manchester, demonstrates the welding, flanging, and general shaping properties of this steel and its suitability for the most intricate boiler work.

Two heavy plates, double folded cold under a steam hammer, and several plates which have been subjected to the explosive force of dynamite, further evidence the beautiful ductility of the material, and fully maintain the high reputation which this firm has always enjoyed for the excellent quality of their steel. Round the base of the stand are displayed polished sections of the beams and bars rolled by the firm, and in two niches facing up and down the avenue are placed several large ingots, blooms, and slabs, together with samples of the raw materials used during the process of manufacture. The Dalzell Steel and Iron Works are situated at Motherwell, ten miles from Glasgow, on the main line of the Caledonian Railway.

The iron works were established in 1871, and the steel works started on ground adjacent in 1880, with four 12 ton melting furnaces. The works have been remarkably successful from the very first, and the plant now includes sixteen melting furnaces, ranging from 15 to 25 tons capacity, two powerful steam hammers, two large plate mills, and one heavy bar mill, together with several smaller mills for lighter sections. The entire plant is of superior design and construction, and the output for the present year is expected to exceed 90,000 tons of finished steel in the shape of plates and bars.

Hadfield's Steel Foundry Company, Hecla Works, Sheffield, occupy the next place, and its exhibit, by its extent and variety, at once attracts the attention of engineers and other users of steel castings. Eight cast steel hydraulic cylinders rising above the other articles form a striking group near the center of the stand; their internal diameters vary from 6 in. to 36 in., the largest cylinder having a length of 20 ft., and the shortest 6 ft. They are excellent examples of hydraulic steel castings, and several of them are turned and polished on the outside to show the soundness of the metal.

Castings for general gearing, including all kinds of spur, pinion, miter, bevel, segment, and worm wheels, are shown in great variety, both moulded from full patterns and by machine. Railway and tramway castings are also well represented by examples of locomotive wheel centers of various sizes up to 8 ft. diameter, horn blocks, roof stay bars, motion plates, crossheads, etc. The well known patent Hecla wheels are also shown, and it may be mentioned that some of these wheels have run 122,000 miles under express locomotives with a total wear of ⅛ in. off the trend, including turning down after running 100,000 miles. This durability is said to be fully equal to that of the best rolled crucible steel tires. Colliery and mining castings

are exhibited in almost endless variety, this department being one of the largest branches of Messrs. Hadfield's business, as will readily be understood when it is mentioned that over two million wheels and axles have been already supplied.

As evidence of the strength and toughness of the material used for these purposes, a pair of hutch wheels and axles which accidentally fell down a mine shaft about 1,800 ft. deep, without other injury than a slight twisting of the axle, may be seen, as well as other specimen castings which have successfully withstood the severest usage. The wants of ship builders and marine engineers have not been largely considered, but the propeller blades, cranks, crossheads, and dredger castings shown, though comparatively few in number, are in point of general excellence not surpassed by any in the exhibition. The production of projectiles for heavy guns has in recent years received a large amount of attention at the Hecla Foundry; and the Shoeburyness trials proved the penetrative power of the Hadfield projectiles to be so far superior to all others, whether of home or foreign manufacture. Particulars of the results, with sketches of three projectiles after piercing steel-faced armor, were given in our issue of 25th May last. In concluding our brief notice of this really splendid exhibit, we may direct attention to the interesting collection of tensile test specimens of both forged and unhammered cast steel, and to the samples of manganese steel with which the name of Hadfield is now inseparably associated. This material is remarkable in many respects, not the least curious of its properties being its very small susceptibility to magnetization, which appears to indicate a large field for its employment in the construction of electrical apparatus.

Mechanical tests of this alloy have given unique results, and some experiments have given the enormous elongation of 50 per cent. on a length of 8 in., coupled with a breaking strain of 70 tons per square inch. The samples shown were used to illustrate papers read by Mr. Robert Hadfield, in February of the present year, before the Institution of Civil Engineers.

Messrs. Charles Cammell & Co., Sheffield, have a large and effective display of their well known specialties in close contiguity with the exhibit just described. A magnificent forging, some 24 tons in weight, intended for the core of a 68 ton breech-loading gun, lies along the front of the stand. It is finished bright on the outside and rough bored, with an electric light at the one end to facilitate examination of the interior. Behind this is grouped a number of smaller ordnance forgings in various stages of completion, forming portions of an assortment of breech-loading rifle guns from 6 in. to 13·5 in. caliber. Several heavy armor plates are shown, and two tested plates, one of solid iron and the other a Wilson steel-faced plate, prove conclusively the superior resisting power of compound armor. One of Messrs. Cammell's compound plates was severely tested in March last at Portsmouth; and a facsimile model of the plate after being struck by two Palliser and three Holtzer forged steel projectiles at a range of 10 yards will be of interest to war ship designers. All failed to pierce the plate, which is certainly one of the finest pieces of armor yet made. Other objects of interest are sections of plates and bolts showing the method of affixing the armor to the supporting backing, an assortment of projectiles and forged shells, various requirements for railway and marine purposes in cast steel, springs of all kinds, cases of tool steel bars, etc.; and, above all, supported on the armor plates, a full sized wooden model of a three-throw crank shaft, 60 tons in weight, made for the well known Cunard steamer Aurania.

Messrs. William Beardmore & Co., Parkhead Forge, Glasgow, have a fine exhibit close to Messrs. Cammell's, and they are the only Scotch exhibitors showing large steel forgings at all comparable with those displayed by the leading English firms represented in the exhibition.

We may first notice a steel three-throw built crank shaft, 21 ft. long, 15½ in. diameter, and weighing 17 tons, supported on two six ton flat ingots, at the west side of the stand. This shaft is for the British India Company's steamer Orissa, now building at Sunderland, and was finished complete within four weeks from receipt of the order. Near it is a hollow built single crank shaft, 7 ft. long, 14½ in. diameter, and about four tons in weight. On the opposite side of the stand is a hollow steel propeller shaft, 21½ in. diameter, over 37 ft. long, finished complete with a 13½ in. diameter hole through center, and weighing thirteen tons. This splendid shaft, which is also supported on two six ton ingots, is intended for the Italian war ship Re Umberto, and was forged from a fifty ton ingot. A test piece cut from the shaft gave a breaking strength of 28·8 tons per square inch and an elongation in a length of 8 in. of 28 per cent. A wooden model of a single-throw hollow steel crank shaft for the same vessel is also shown. It measures 9 ft. 6 in. in length, 19½ in. diameter, with a 9½ in. hole through center. The ingots alluded to as supporting the two large shafts will be rolled into shell plates for the boilers of the cruisers now being built at Barcelona for the Spanish government. A very large boiler plate is shown at the south end of the stand, and in the center a boiler front plate flanged for three furnaces. Several dished hemispherical plates for submarine mines; cases containing bolts, rivets, etc., and sections of the bars rolled by the firm; a specially interesting collection of test specimens, including some remarkable torsion and multiple folding tests; and a model of "Samson," the largest slabbing hammer in Scotland, complete the list of the principal items of an exhibit which is certainly one of the most instructive of its kind in the exhibition. The Parkhead Forge was started originally in 1835 by Mr. Reoch. The works afterward became the property of Messrs. Robert Napier & Sons, and Mr. Rigby, inventor of the well-known steam hammer bearing his name, was engaged with them as manager, till he, in partnership with Mr. Beardmore, father of the present leading proprietor, acquired the concern in 1861. The Parkhead Forge has grown with the growth of the shipbuilding and engineering industries of the Clyde, the principals having always been prompt to adopt any improvements necessary to enable them to keep pace with the times. Messrs. Beardmore & Co. were the second firm in Scotland to commence the manufacture of Siemens steel. Starting in 1879, they have now in constant work eight large open hearth furnaces of the most approved construction. Their rolling mill plant enables them to turn out the largest plates and heaviest bar sections required by boiler makers and shipbuilders. The appliances for making and finishing the largest engineering forgings, both in iron and steel—either solid or hollow—are of the most complete description—a statement borne out by the fact that such recent additions to our steel clad navy as the Victoria, Sanspareil, Trafalgar, Nile, and many others have received their heaviest engine forgings from Parkhead.

Messrs. John Spencer & Sons, Newburn Steel Works, Newcastle-upon-Tyne, have contented themselves with a stand of moderate proportions, chiefly devoted to patented specialties of which they are manufacturing licensees. Among these we notice a small two-throw Foster's patent crank shaft; a single throw Dickenson's patent crank shaft, with section of same to show soundness of metal; and a propeller blade tinned to prevent corrosion by Johnston's patent method. A cast steel locomotive driving wheel center, 6 ft. 6 in. diameter, is also shown, and some miscellaneous castings and forgings, and samples of tool steel. The most interesting portion of this exhibit consists of a number of small cast articles, described by the makers as "Newburn homogeneous iron castings." This homogeneous iron is said to be a special description of very soft steel, giving a breaking strength of from 22 to 25 tons per square inch, and an elongation of 30 to 40 per cent. It is stated to be specially adapted for making castings to replace intricate smith work and forgings; and as in most cases no annealing is required, articles cast in this material can be rapidly supplied. The samples shown resemble in appearance the well known "Mitis" castings, and if the statements of the makers stand the test of practical trial, homogeneous iron castings will no doubt find a wide field of usefulness.—*The Engineer* (*London*).

SODIUM AND ALUMINUM.

THE attention of chemists and metallurgists has, from time to time, during the last few years been directed to the notices of new processes for the manufacture of sodium and aluminum, two metals that have hitherto been little more than scientific curiosities. One of the first of these was the Cowles electric process, which consists in the reduction of corundum, an ore of alumina, in the presence of charcoal and granulated copper, and which is now carried on at Lockport, in the State of New York. The Cowles process, however, does not appear to have given pure aluminum up to the present time, and it is regarded doubtful whether it will ever do more than give aluminum alloys. This was followed by the Castner sodium process, which, as we have already explained, differs from the old Deville process, chiefly in reducing a fused mass of soda compound, by the device of so weighting the carbon, which effects the reduction, with iron that the two ingredients are in perfect admixture as the liquid circulates in the crucible under the action of a comparatively low temperature. A third process, with which our readers have been made familiar, bears the name of Dr. Kleiner, of Zurich, and consists in extracting the metal by electrolysis at a low temperature from cryolite, a double fluoride of sodium and aluminium. In this country, however, the only aluminum process that has been brought into successful operation up to the present time is that known as the Castner process. To see this process at work a large party of scientists and others were invited to visit the new works of the company at Oldbury, near Birmingham, on Saturday, July 28 last. Leaving Euston by the ordinary 9:30 A. M. train, the party reached Oldbury shortly before one, and after partaking of a substantial luncheon, they were shown over the new works by Lieutenant-General Sir Andrew Clark, chairman of the company, Sir Henry Roscoe, F.R.S., one of the directors and chemical adviser, and Mr. H. Y. Castner, the inventor of the process, and managing director. Much surprise was expressed at finding the works in so advanced a condition, considering that they were only commenced in October last, and that the whole of the plant and much of the machinery was novel in character. The works had been commenced experimentally about a fortnight before, but they did not begin operations on a really practical scale until recently.

The Castner sodium process, as is now tolerably well known, is a modification of the familiar Deville process—the only process that has hitherto yielded pure aluminum on a commercial scale. It differs from the ordinary Deville process, however, in carrying on the process of reduction at the comparatively low temperature of 800 deg. Cent., whereas in the old process the temperature is usually 1,500 deg. Cent. This modification allows of the employment of steel vessels of comparatively large size, instead of the small wrought iron tube that was previously called for by exigencies of temperature, and is attended by a great deal less wear and tear of plant, as well as by a much larger production. Since the original Castner patents were obtained, their author has developed other improvements, alike in his sodium and his aluminum processes, the principal of which are his system of charging the crucibles hot, and the use of larger crucibles, whereby a heavier charge can be treated in a shorter period. The crucibles, moreover, are now charged with the fused mixture, instead of receiving the solid ingredients in the cold state. The conjoint result of these several improvements is that the price of sodium has been reduced from about 4*s.* or 5*s.* to 9*d.* per pound, while aluminum, which formerly could not be purchased for less than about 50*s.* per pound, and was only produced on a commercial scale at very few small works, is now manufactured at 10*s.* to 15*s.* per pound, and sold at 20*s.* per pound in practically unlimited quantities. The cost has been cheapened at every stage of the process employed, and in operating on a large scale all the claims then made seem to have been amply verified.

The first process witnessed by the visitors to Oldbury was the making of the carbon compound, which is obtained by manufacturing from a mixture of melted pitch and iron a coke which is afterward finely ground and employed as the reducing material in the production of sodium from the caustic soda. Alongside of this operation was shown that of the manufacture of sodium. For this part of the industry a very fine plant of twenty furnaces is employed, ranged in two rows in a building immediately behind a plant of Wilson producers, whereby the gas is generated that is employed in the processes of heating and reduction. The caustic soda and the carbide of iron, employed as the raw materials of this process, are kept at a temperature of 600 deg. Cent. for about an hour and a half. During this time the sodium is distilled into small iron condensers. About 6 lb. of caustic soda produce 1 lb. of sodium and 5 lb. of carbonate, and about 3 lb. of sodium and 10 lb. of chloride are employed to produce 1 lb. of aluminum. There is thus a considerable amount of handling of materials required, in order to get the final product. The residue obtained from the sodium process, which consists of 80 per cent. of carbonate of soda and 20 per cent. of metallic iron, is lixiviated in special apparatus, and the solution of the soluble carbonate is pumped over to the alkali works of Messrs. A. Chance & Co., from whom the Oldbury company purchase their caustic, and to whom they sell their carbonate under contract. The metallic sodium, after being collected from the condensers in dry iron pots, is brought into a separate shop, where it is packed in oil for shipment or for use on the premises.

For the manufacture of the double chloride of aluminum and sodium, the company employs twelve regenerative heating furnaces, each 20 ft. high by 30 ft. long and 15 ft. wide. There are five retorts in each furnace, or sixty retorts in all. The capacity of the plant is about 6,000 lb. per day. The furnaces are charged with a mixture of alumina and carbon. When the charge has reached the proper temperature, which takes about an hour, chlorine gas is admitted in definite proportions, the amount being regulated by a series of valves. The process is continued for about two days, about 100 lb. of chlorine being passed into the furnace daily. During the two days of the operation the double chloride is being continually distilled from the charge, and when the whole of the latter has been got out, the chlorine gas is stopped and the double chloride obtained is withdrawn from the condensers in the form of a solid crystalline mass of about 2¼ cwt. The double chloride contains about 12 per cent. of aluminum, and yields under treatment with sodium about 10 per cent. of aluminum. The plant employed for the generation of chlorine is a modified Weldon plant, and is declared by Sir Henry Roscoe to be the most perfect Weldon plant extant. The same authority, speaking of the double chloride process as a whole, has just reported that "the plant necessary for carrying on this process is very extensive, and much of it is entirely novel in its character, and, in consequence, it is not in quite so forward or perfect a condition as that of the sodium manufacture; but portions of it are complete, and these have been at work already satisfactorily, while the remainder is on the eve of completion." The double chloride, on being withdrawn from the furnaces or stills, is stored for use in air-tight chambers, each capable of containing 2 tons.

In the treatment of the chloride by sodium so as to produce aluminum, two special descriptions of furnace are employed at the Oldbury works. One of these has a slanting hearth, somewhat after the form of a bath tub. The furnace is heated by gas, as are all the furnaces and other apparatus used throughout the works. The temperature of the furnace is about 1,000 deg. Cent. The charge consists of about 25 lb. of sodium, 80 lb. of chloride, and 30 lb. of cryolite, which is used as a flux. These materials are charged into the furnace through a hopper at the top, and after an interval of about an hour and a quarter the slags are drawn off, and the aluminum is run out into a cup at the bottom. About 18 lb. of aluminum are obtained from each charge. The second form of furnace employed does not materially differ from the one just described, except in regard to the method of withdrawing the charge of aluminum, which is allowed to settle to the bottom of a crucible, whence it is withdrawn by removing a plug in the bottom. In the latter case the aluminum is found enveloped in its slag, the latter having to be broken before it is withdrawn. Both furnaces are now under careful experiment, and it is probable that one will be definitely adopted before long. The aluminum is cast in the form of small pigs not unlike the shape of pig iron. Each pig weighs about a pound. The visitors, while at Oldbury, were each presented with a small piece of aluminum, polished on one surface and unpolished on the others, which showed the remarkable lightness and brilliancy of the metal. They were also shown in the office of the works aluminum sheets of remarkable thinness and thin aluminum wire capable of supporting a very high strain.

The chemical reactions that occur in the manufacture of aluminum are as follows:

1. The sodium process—

$$6\,Na\,HO + Fe\,C_3 = 2\,Na + 2\,Na_3\,Co_3 + 6\,H + Fe.$$

2. The chlorine process—

$$Al_2\,O_3 + 3\,C + 6\,Cl + Na\,Cl = Na\,Cl\,Al_2\,Cl\,6 + 3\,CO.$$

3. The aluminum process—

$$Al_2\,Cl_6 + 6\,Na = 6\,Na\,Cl + 2\,Al.$$

Some years ago the late Mr. Walter Weldon, who was regarded as one of the first authorities on the subject, gave the approximate cost of each step in the Deville aluminum process, as carried on by M. Pechiney, of Salindres, France, as follows:

	Per cent.
Production of the alumina	10
" " double chloride	33
" of sodium and reduction of aluminum therewith	57
Total	100

Assuming that the cost of the production of the metal at the same time was about 40*s.* per pound, the cost of each step of the process would have been as under:

Item.	*s.*	*d.*
1. Cost of alumina	4	0
2. " chloride	13	0
3. " sodium and reduction	23	0
Total per pound of aluminum	40	0

All three steps of the process have been cheapened by the Castner process, but of course in varying degrees. The alumina used in the production of aluminum by

the Castner process does not quite cost a shilling. The production of chlorine and the process for the production of the chloride of aluminum have been successfully cheapened by Mr. Webster at the Solihull works, and Mr. Webster's improvements, together with those adopted or originated by Mr. Castner, have still further reduced the cost of manufacture at Oldbury.—*Engineering.*

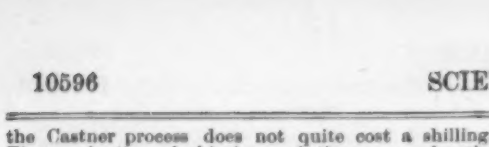
AUTOMATIC MARINE FOG SIGNALING.

By Captain H. BERKELEY, R.N.

IN answer to Mr. Channing's question in Parliament regarding fog signals, Sir Michael Hicks-Beach said that the matter was at present receiving the serious consideration of the "Board of Trade," and that a committee had been formed by his predecessor in office, consisting of Admiral Sir F. L. McClintock, Sir George Nares, Sir Digby Murray, Captain Bowden Smith, R.N., Captain C. P. Wilson (the Registrar-General of Seamen), Thos. Gray, Esq., C.B. (Assistant Marine Secretary to the Board of Trade), and the secretary at Lloyd's. Sir M. Hicks-Beach also said the attention of the "Board of Trade" had been directed to the collision between the steamers Celtic and Britannic, and the system in vogue for signaling in fogs at sea.

In view of the fact that an international council is to be called, to meet in Washington, U. S. A., to take into consideration the question of an international code of signals to be used at sea, we think the time is opportune for communicating the following facts relating to signals in thick and foggy weather. That the present arrangement for using steam whistles does not meet the emergencies of the case is only too evident; for, precisely when most necessary, *i. e.*, in dense fogs in the British Channel as well as on the high seas, the system breaks down altogether, and exposes alike her Majesty's costly ironclads and richly laden merchant vessels to the same disaster. On the one hand we have to deplore such losses as the Vanguard; on the other, the collision between the Celtic and Britannic. Were it at all necessary to our purpose we could adduce numerous other instances of calamities at sea, caused for the most part by a want of knowledge of points from which ships were approaching each other; or, to put the matter plainly, the *inability to inform each other of the courses they were severally steering.* With the following scheme of marine fog signals such inability need no longer exist. This is no new or recondite theory, but one which has been before the public for nine years past, and the more these signals have been tested, the better they have stood the trial. But here, in this country, we are exceedingly conservative as regards anything new, especially if it appertains to the sea, over which we seem to accept the responsibility of knowing "all about it," whatever it may be; in effect saying "Whatever is, is," and "Whatever is, is best."

As an indication of what we mean, there is at the present time an officially recognized fog horn, and of what does it consist? Why, it is a preposterous penny whistle made to perform by the aid of the "parlor bellows." Here it is. Need we say more?



THE PATTERN FOGHORN APPROVED AND USED IN FOGS AT SEA.

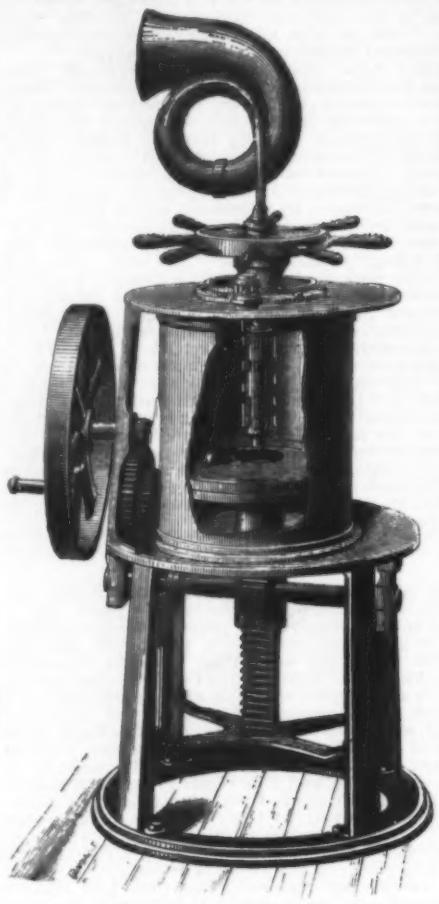
The president of the Board of Trade, in reply to Admiral Sir John Hay, K.C.B., F.R.S., etc., in the House of Commons, said "his attention had been called to Captain Barker's system of signaling, the merits of which he was fully aware of, as it had been successfully investigated by the Royal United Service Institution." The National Board of Steam Navigation, U.S.A., representing the entire steam vessel interest of the country, has recommended the adoption of Capt. Barker's system.

The council representing the Mercantile Marine Service Association of Liverpool (the largest organization of seafaring men in the world) offered their gold medal for "the best international system of course, fog, and night signaling, for ships and steamers, that will minimize the risk of collisions and prevent the loss of life and property at sea." If we value the opinions of seafaring men, no further evidence of the necessity for the change will be sought for.

The court of inquiry held at New York, Celtic v. Britannic, confirmed the opinion expressed by the Mercantile Marine Service Association, by finding the cause for the collision to be the absence of the necessary distinctive course signals to be used in fogs. During the same year, the directors of the Clyde Steamship Owners' Association, Glasgow, passed a resolution favoring the adoption of course signals to be used in foggy and dense weather. In February last the United States Senate passed a bill calling for an international conference on signaling a vessel's course in fogs, and saving life at sea generally; therefore, we submit that it is imperative for all vessels to make known their approximate compass course in fogs.

Capt. W. B. Barker has for several years past devoted his energies to perfecting a complete arrangement for ships and steamers that will undoubtedly prove successful in fogs at sea when lights cannot be sighted; by this arrangement all necessary signals may be regulated and delivered with a certainty. This is accomplished by a revolving disk marked to correspond with the four cardinal and four intermediate points of the compass. The machinery for working the code of signals is automatic and not liable to derangement; therefore we confirm the opinions expressed by the association above mentioned, which awarded their gold medal to Capt. W. B. Barker, for his invention. It is needless here to describe the nature of the signals at present in use, or to comment on their intrinsic value; they have been fairly tried and found wanting. As the *United Service Gazette* observes, "We shall not keep abreast of the times unless we break with the received traditions of the Circumlocution Office."

The risk of collisions is greatly enhanced by the extreme length of vessels whenever their courses lie at right or obtuse angles to each other; these risks can be minimized by each making known to the other the course steered, and for the purpose we submit a code of signals, systematically arranged and worked by mechanical means, as below shown.



BARKER'S FOGHORN.

The code consists of eight signals, composed of long sounds and short blasts; each of the cardinal points of the compass is represented by a three-blast signal, viz.:

North to northeast, one long sound followed by two short blasts, as indicated, — ▪ ▪

East to southeast, one long, one short, and one long sound, viz., — ▪ —

South to southwest, two short blasts, followed by one long sound, viz., ▪ ▪ —

West to northwest, one short blast, one long followed by a short blast, viz., ▪ — ▪

The four intermediate points are distinguished by a four-blast signal.

Northeast to east, one long sound, followed by three short blasts, viz., — ▪ ▪ ▪

Southwest to west, three short blasts, followed by one long sound, viz., ▪ ▪ ▪ —

Southeast to south, one long sound, two short blasts, followed by one long sound, viz., — ▪ ▪ —

Northwest to north, four short blasts, viz., ▪ ▪ ▪ ▪

This code is easily learned, as all signals commencing with a *long sound* represent *easterly courses*, the *westerly courses* are distinguishable by the *short blast* being given first in each instance, all signals to the northward *end with a short blast*, and those to the southward *with a long sound.*

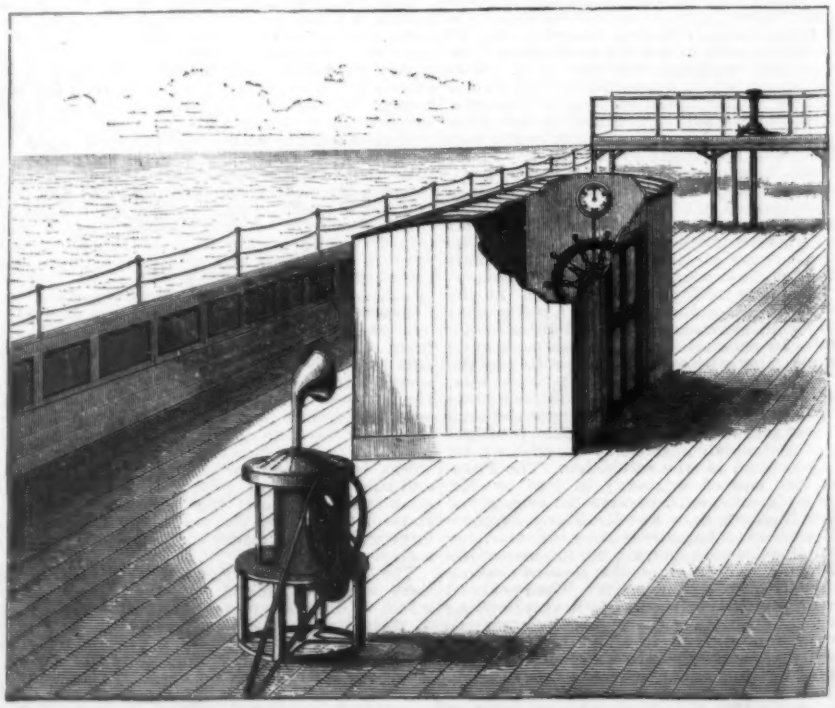
By the first and last blasts, or sound of any signal, the vessel's course is limited to a quadrant of the compass, *i. e.*, within 90 degrees. This system of arrangement is superior to any hitherto submitted, as it plainly shows when compared with the seventy-nine suggestions submitted to the Society of Arts.

The Mercantile Marine Service Association of Liverpool has unanimously approved this system.

The working of this ingenious plan is of the most reliable and perfect description. The officer in charge has before him on the bridge a horizontal dial, having on it a fixed index always pointing ahead. The dial plate revolves either to port or starboard, and has engraved on it the cardinal points of the compass and the principal subdivisions, N.E., S.E., N.W., and S.W. Strong and simple mechanism connects this with an indicator fixed in the wheel house in a vertical position, immediately in front of the steersman, who requires no other guide but the index on it. At the moment it is desired to alter the ship's course, the slightest turn of the bridge dial to port rings one bell to tell the steersman to port his helm, and the course he is to steer is indicated to him on the dial in front of the wheel, this dial having in addition to the points named above eight others, N.N.W., N.N.E., E.N.E., E.S.E., S.S.E., S.S.W., W.S.W., and W.N.W. Thus, without the risk of mistaking the order in "passing the word," an instantaneous communication is established between the officer and the helmsman, and it is in effect as though the officer himself was obeying his own order, as there is no intermediary between him and the one who carries out his behest, save the unerring dial plate. But, in addition to this, the bridge dial at the same instant locks the fog horn to the code signal for the particular course the ship is altered to, and emits on the instant that signal which indicates to all other vessels within hearing the exact course she is steering, while informing them by the first blast whether she is a steam or sailing ship. Our illustration shows the apparatus as placed on the vessel. It consists of a sound-producing instrument; dial plate; cylinder for holding compressed air; code cylinder; driving wheel; rack and pinion, and ratchet for producing automatic action of the mechanism and plunger. —*Ill. Naval and Military Magazine.*

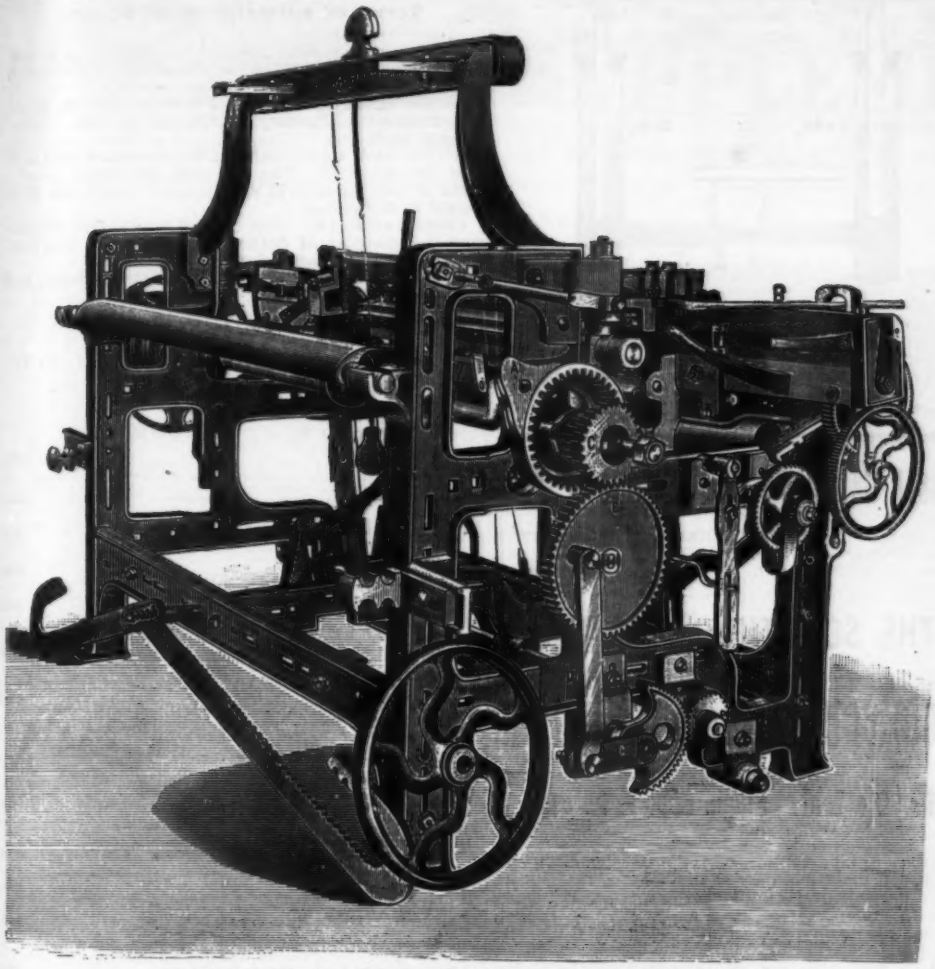
IMPROVED POWER LOOM.

WE illustrate a new power loom of remarkably simple construction. The tappet shafts, picker shaft, and rod are omitted, as is also the gearing usually employed for driving them. The picker, instead of being driven by means of the usual picker shaft and strap, is actuated by a short arm formed on the pin on which the cranked lever, B, is centered. The arm carries a small bowl which is operated by a cam, A, in the same way as in the ordinary picker motion. The end of the lever, B, passes through the picker and is drawn back after each pick by means of a spiral spring attached to a tail piece, the motion of the lever taking place in a horizontal plane. The cam is rotated from the crank shaft by means of a pinion gearing with an internal wheel. Keyed to the end of the crank shaft is a spur pinion, C, engaging with a wheel, C, which by means of a connecting rod communicates an oscillating motion to the toothed quadrant at the lower part of the loom. The quadrant gears with a spur pinion fixed on the end of a cross shaft, the movement of which is utilized to work the healds and form the shed, this shaft rotating alternately in opposite directions. In order to insure that the dwell of the healds necessary to keep open the shed during each pick is maintained, the shape of the quadrant is such that no movement is given to the pinion during one portion of the quadrant's oscillation, so that all danger of locking of the shuttle is avoided. This brief description will show that these improvements have been made with a view to simplification. If subsequent use shows that the picker motion is perfectly satisfactory, one of the most troublesome parts of a loom will have been abolished,



DIAL PLATE, INDICATOR, AND FOGHORN IN POSITION ON DECK.

as when the ordinary picker bands are used the wear is excessive; in addition to which the direct impulse given to the picker is a good feature of the design. The treading motion is also very simple and effective. We are informed that the improvements can be applied to old looms at a small cost, and that looms so converted turn out very satisfactory work. The motion is in the hands of the Patent Power Loom Company, Lower Broughton, Manchester, where it can be seen in operation.—*Industries.*



IMPROVED POWER LOOM—GENERAL VIEW.

EMERY GRINDING MACHINERY.

MESSRS. L. STERNE & CO., limited, of the Crown Iron Works, Glasgow, show an interesting collection of machine tools, some of which we illustrate. Fig. 1 is an automatic surfacing machine in which the abrading tool is an emery wheel.

This machine is especially designed for surfacing machine parts which have usually to be planed and afterward filed and scraped. It does the work much more rapidly than planing, and no filing is necessary, and very little scraping is required. The general design of the machine is shown in the illustration. The table has an automatic longitudinal motion and can be set to any stroke within the limits of the machine, the feed up to the wheel being either by hand or automatic. The former is generally preferred, as the motion necessary to take a considerable cut is very slight, and it is more under the control of the workman. It will be seen by the illustration that four narrow wheels spaced apart are used in place of one wide one. In this way the work is kept cool, while the number of cutting edges being increased permits of quicker work. In order to enable the whole surface of the work to be ground, and also to keep the wheels true and of equal diameter, the wheel spindle has a longitudinal motion imparted to it by an ingenious wormwheel and link arrangement at the end. This is adjustable, so that the extent of the movement can be varied as required. The bearings and sliding surfaces are well protected from emery dust. This machine is designed to work equally well with hardened steel, chilled cast iron, soft steel, wrought iron, soft cast iron, or brass. It is well adapted for grinding slide bars, slide valves, and similar parts.

Another machine shown by this firm is the automatic wheel tooth cleaner, which we illustrate by Fig. 2. The general design of this machine will be easily gathered from the engraving. It will clean out the teeth of spurwheels or straight-toothed wormwheels. The emery wheel is shaped on the periphery to the space between the teeth of the wheel to be cleaned, and is carried on a vertical slide which has a reciprocating motion imparted by means of a connecting rod and disk, actuated by a worm and wheel from the countershaft at the base of the machine. The wheel spindle is driven by a belt at each end, and is made in two parts and coupled at the center, so that the emery wheel can be removed and another inserted without having to interfere with the bearings or take out the spindle. A swinging frame at each side, carrying a couple of guide pulleys, takes up the slack of the driving belts, and the whole machine works with great smoothness and regularity. The wheel being cleaned is moved round one tooth each time when the emery disk has cleared the wheel at the bottom of its stroke. Each space, therefore, is traversed twice by the disk. The feed motion can be adjusted for any diameter, pitch, and width of wheel within the limits of the machine. A spring lever automatically holds the wheel firmly while the emery disk is doing the work. In this way the teeth are equally spaced and are each ground to the same shape and at the same distance from the center. About 2,000 teeth can be operated upon in one hour.—*Engineering.*

PUMPING SOLVENTS INTO BOILERS.

THE use of something to remove scale or to prevent its formation in steam boilers is so commonly necessary that some sort of apparatus for introducing it into a boiler every day in the form of a solution, and without interfering in the least with the operation of the boiler, will be found a most desirable, convenient, and economical thing.

In most steam plants, if the use of a solvent is found to be necessary, there is no way to get it into the boilers without shutting them down, cooling off, and introducing it through the man hole or hand hole. If this is done only when the boilers are opened up for cleaning, of course no extra expense is involved, but, as a rule, the stoppages for this purpose are so far apart that the use of the solvent amounts to very little, as in the natural course of running it will be entirely blown out and lost long before the next charge can be introduced. If a stop is made as often as the solvent should be introduced, for the special purpose of putting it in, great and unnecessary expense is involved. The loss entailed by one such stoppage would more than pay for a proper apparatus for introducing it daily or oftener if desired, and in the form of a solution. And it is plain that small quantities in solution introduced at short intervals will be much more effective than a large quantity at longer intervals, and when water is very bad a much greater quantity of the solvent can be used in a given time than can be where large quantities are put in at longer intervals. For

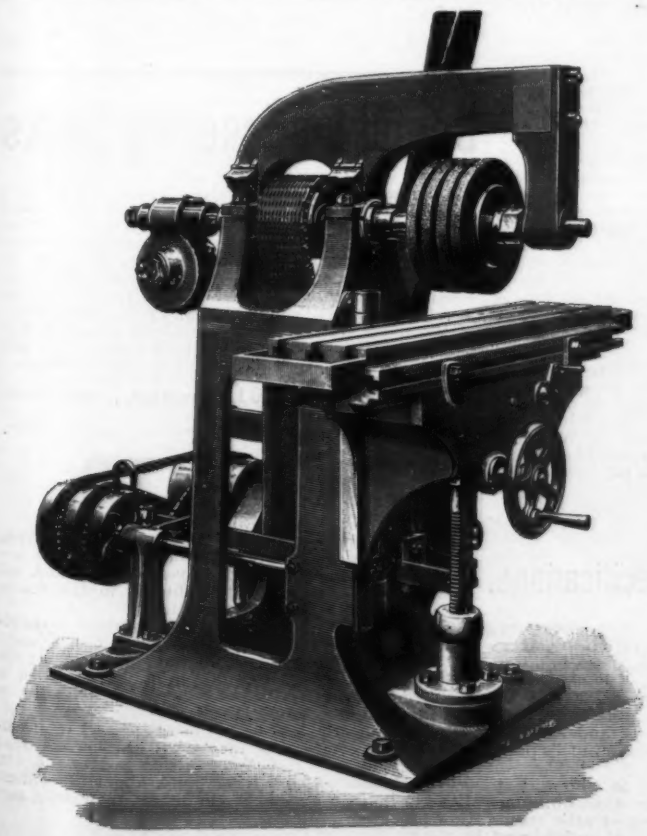


FIG. 1.—AUTOMATIC SURFACING MACHINE.

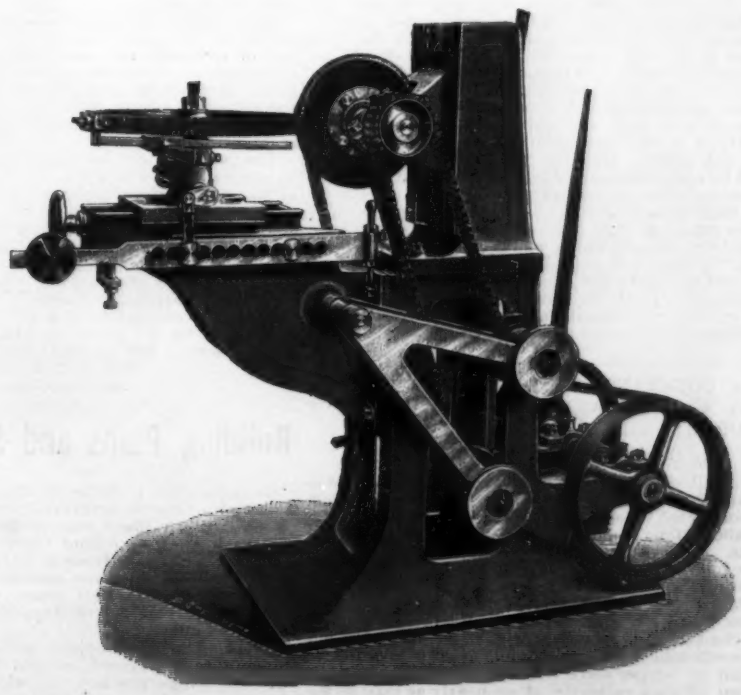
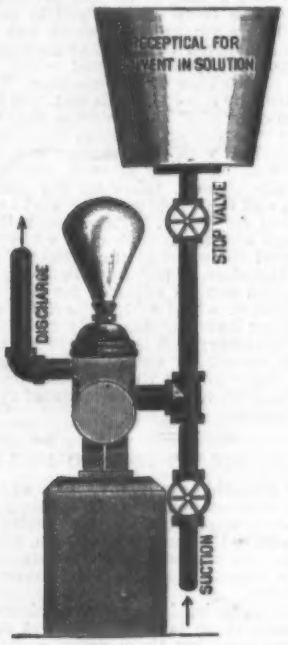


FIG. 2.—WHEEL TOOTH CLEANING MACHINE.

EMERY GRINDING MACHINERY AT THE GLASGOW EXHIBITION.

illustration, with some waters a charge of thirty pounds of soda ash once a month might cause serious trouble for a while after it was put in, but one pound a day could not possibly injuriously affect the working of the boiler.

Our illustration in this issue shows a very simple and convenient method of attaining the desired result, and the apparatus can be attached to any pump or injector at a very slight expense. We have shown it attached to an ordinary steam pump. An explanation of the cut is hardly necessary. The practical engineer will understand it at a glance. To the upper end of the suction pipe another pipe is connected by means of the T, and extended to any convenient height. This pipe is provided with a stop valve, and carries on its upper end 'a receptacle (in making the cut our artist was a trifle lame in his spelling of the word "receptacle," but this will not interfere with the efficient



working of the actual apparatus), for the solution which it is desired to put into the boiler. This may be an iron or a wooden vessel, as may be preferred, and of any required size. This vessel is filled with the solution while everything is running as usual. If the pump is drawing its supply, the only thing necessary to do is to open the valve connecting with the vessel above, and its contents will be put into the boiler with a very few strokes of the pump, when the valve may be again closed until it is wanted for use again.

If, on the contrary, the pump is drawing its supply from some source which exerts pressure, more or less, as is frequently the case, the stop valve in suction pipe should be closed while the connection to the open vessel of solvent is open, or it would be driven out of the top of the vessel. But, in either case, a few moments suffice to complete the operation without any interruption to the operation of pump or boilers.

Another advantage which in many places would incidentally accrue from the attachment of this apparatus as shown is this: It can be made to serve as an air chamber to the suction pipe of the pump. Under some circumstances an air chamber here is a necessity, and in no case is it a disadvantage. With the stop valve in the pipe connecting with the solution placed well up, quite a large air chamber will be formed above the top of the suction pipe, which will make as good an air chamber as the maker of the pump could furnish. In making the attachment, if its utilization for this purpose is desired, a portion of the pipe should be made larger in its middle portion than would be necessary for the purpose of introducing the solvent merely, reducing at the lower end where it connects with suction pipe, and near the upper end, to obviate the necessity of using a large stop valve. If the air chamber is not desired, the stop valve in the upper pipe should be put down as close to the suction pipe as it can conveniently be connected.

The same attachment can be made to the suction of a power pump or to an injector. Owing to difference in the circumstances which would be found in different places, the details of the connection might vary somewhat, but the principle would remain the same, and any ordinarily intelligent engineer should be able to get it up without difficulty, and at an expense of a very few dollars.—*The Locomotive.*

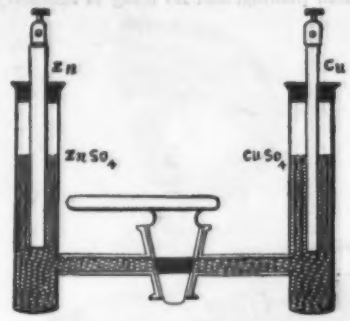
ON A CONSTANT DANIELL CELL, FOR USE AS A STANDARD OF ELECTROMOTIVE FORCE.*

*By COSMO I. BURTON, B.S.C., F.C.S.

THIS cell consists of two tubes about three inches long and half an inch in diameter, sealed at one end, and connected together near the closed end by a glass tube about four inches long, having a glass tap in the middle.

The hole through the plug of the tap is filled with plaster of Paris, made as nearly as possible flush with the glass surfaces. This plaster plug serves as a porous septum between the two tubes, which represent respectively the two compartments of a Daniell cell—the one tube containing a copper rod immersed in a saturated solution of copper sulphate, the other a zinc rod in a solution of zinc sulphate, of as nearly as may be the same density as the copper solution. The cell is designed for use only with the quadrant electrometer, and must never be short-circuited.

When the cell is used the tap is turned "on," *i. e.*, so that the ends of the plaster plug are opposite the two tubes containing solutions. Immediately that the observations are completed, the tap is turned off, and



so diffusion of the solutions completely prevented. The tap is made of the peculiar shape shown in the diagram, in order that it may only be turned in one direction, and so the possible transfer of a minute quantity of the one solution into the opposite tube is avoided.—*The Electrician.*

* From the *Proceedings* of the Royal Society of Edinburgh.

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

THE SCIENTIFIC AMERICAN

Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

MUNN & CO., Publishers,
361 Broadway, New York.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. BIOLOGY.—The Micro-organisms of Air and Water.—By PERCY F. FRANKLAND.—An exhaustive and popular treatment of this subject, with details of methods and results.—3 illustrations..... 10597

II. BOTANY.—Flowering Trees and Shrubs.—Philadelphia or mock oranges and their availability in landscape gardening..... 10597

III. CHEMISTRY.—Maize or Corn Oil.—The manufacture, properties, uses and analysis of this product..... 10599
Some Phases in the Progress of Chemistry.—An abstract of Prof. C. E. MUNROE'S address before the A. A. A. S. at their Cleveland (1888) meeting..... 10599
The Chemical Constitution of Pearls.—By GEORGE HARLEY, M.D., F.R.S., and HARALD S. HARLEY.—Examination of oyster and cocoanut pearls; interesting statement of their properties, analysis and other points..... 10599

IV. CIVIL ENGINEERING.—The Tancarville Canal.—A canal between Harve and the Seine, now in process of construction. Notes of other improvements of the port.—2 illustrations..... 10599

V. ELECTRICITY.—On a Constant Daniell Cell, for Use as a Standard of Electromotive Force.—By COSMO I. BURTON, B.S.C., F.C.S.—A new Daniell battery in which diffusion of the solutions is completely avoided.—1 illustration..... 10598

VI. GEOGRAPHY.—The Census Maps of the United States.—The conic and polyconic projections of the United States—a suggestion in geography for the census..... 10599

VII. MECHANICAL ENGINEERING.—Emery Grinding Machinery.—Automatic surfacing and wheel tooth cleaning machine, using emery wheels as the cutting or abrading agents.—2 illustrations.. 10597
Pumping Solvents into Boilers.—An effective apparatus for the introduction of scale preventives and solvents into steam boilers.—1 illustration..... 10597
The Sun Motor.—By Capt. JOHN ERICSSON.—The distinguished inventor's last improvement—a parabolic reflector for concentrating the sun's rays.—2 illustrations..... 10602

VIII. METALLURGY.—Sodium and Aluminum.—The Castner process now in operation at Oldbury, England, with a description of the practical working of the process..... 10599
Steel at the Glasgow International Exhibition.—A graphic description of the remarkable exhibits shown at Glasgow..... 10600

IX. NAVAL ENGINEERING.—Automatic Marine Fog Signaling.—By Captain H. BERKELEY, R.N.—Fog signaling machinery of the type invented by Captain Barker, which automatically gives a distinctive signal for each course of the vessel.—3 illustrations 10600

X. ORDNANCE.—The Bofors Cast Steel Gun.—By Captain O. E. MICHAELIS, Ph.D., United States Army.—The production of guns from unforged open hearth steel by casting process.—Their excellent qualities and freedom from blowholes.—A plea for cast steel ordnance..... 10595

XI. PHYSICAL GEOGRAPHY.—The Great Japanese Volcanic Eruption.—A recent catastrophe in Japan, with its fearful results 10595
The Great Muir Glacier in Alaska.—A description of this immense glacier, far surpassing in size the Swiss glaciers..... 10599
Yellowstone Park.—The geysers, hot springs, and other wonderful features of the park described and illustrated.—11 illustrations 10593

XII. TECHNOLOGY.—Improved Power Loom.—An effort at simplification of the power loom—an improvement applicable to already existing machines.—1 illustration..... 10596

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American,** Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.